

AD-A266 618



DEPARTMENT OF THE NAVY
NAVY EXPERIMENTAL DIVING UNIT

321 BULLFINCH ROAD
PANAMA CITY, FLORIDA 32407-7015

2

IN REPLY REFER TO:

DTIC
ELECTE
JUL 07 1993
S A D

NAVY EXPERIMENTAL DIVING UNIT

REPORT NO. 5-93

EX 24 FULL FACE MASK

CWO3 K. R. JONES
LT L.J. CREPEAU

MAY 1993

DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited

Submitted:

K.R. Jones
K.R. JONES
CWO3, USN
EOD Projects Officer

L.J. Crepeau
L.J. CREPEAU
LT, MSC, USNR
Research Psychologist

Reviewed:

M.E. Knafelc
M.E. KNAFELC
CDR, MC, USN
Senior Medical Officer

B.D. McKinley
B.D. McKINLEY
LCDR, USN
Senior Projects Officer

J.R. Clarke
J.R. CLARKE, Ph.D.
Scientific Director

M.V. Lindstrom
M.V. LINDSTROM
LCDR, USN
Executive Officer

Approved:

Bert Marsh
BERT MARSH
CDR, USN
Commanding Officer

93-15306



93 7 00 03 1

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION Unclassified		1b. RESTRICTIVE MARKINGS	
2a. SECURITY CLASSIFICATION AUTHORITY		3. DISTRIBUTION/AVAILABILITY OF REPORT	
2b. DECLASSIFICATION/DOWNGRADING AUTHORITY		DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) NEDU Report No. 5-93		5. MONITORING ORGANIZATION REPORT NUMBER(S)	
6a. NAME OF PERFORMING ORGAIZ. Navy Experimental Diving Unit	6b. OFFICE SYMBOL (If Applicable) 03E	7a. NAME OF MONITORING ORGANIZATION	
6c. ADDRESS (City, State, and ZIP Code) 321 Bullfinch Road, Panama City, FL 32407-7015		7b. ADDRESS (City, State, and Zip Code)	
8a. NAME OF FUNDING SPONSORING ORGANIZATION Naval Sea Systems Command	8b. OFFICE SYMBOL (If Applicable) 00C	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER	
8c. ADDRESS (City, State, and ZIP Code) 2531 Jefferson Davis Highway, Arlington, VA 22242-5160		10. SOURCE OF FUNDING NUMBERS	
		PRGGRAM ELEMENT NO.	PROJECT NO. TASK NO. WORK UNIT ACCESSION NO.
11. TITLE (Include Security Classification) (U) EX 24 Full Face Mask			
12. PERSONAL AUTHOR(S) CWO3 K. R. Jones and LT L.J. Crepeau			
13a. TYPE OF REPORT Test Report	13b. TIME COVERED FROM AUG 92 TO APR 93	14. DATE OF REPORT (Year, Month, Day) May 1993	15. PAGE COUNT 50
16. SUPPLEMENTARY NOTATION			
17. COSATI CODES		18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)	
FIELD	GROUP	SUB-GROUP	
19. ABSTRACT (Continue on reverse if necessary and identify by block number)			
<p>This report examined unmanned and manned performance of the EX 24 Full Face Mask (FFM), determining whether the FFM provides acceptable levels of breathing resistance and speech intelligibility in both open and closed circuit modes when used with the MK 16 MOD 0 UBA. Additionally, evaluating the interface of the FFM with the Emergency Breathing System Type II (EBS II) as well as the MK VIII Seal Delivery Vehicle (SDV) boat air in their current configurations.</p> <p>Unmanned results were obtained from studies evaluating Work of Breathing (WOB) in: (1) the open circuit mode to 40 msw (130 fsw) at 21.1°C (70°F) with air provided from a simulated SDV boat air source; (2) the open circuit mode to 46 msw (150 fsw) at -1.7°C (29°F) with air provided from the EBS II; and (3) the closed circuit mode to 91.9 msw (300 fsw) at -1.7°C (29°F).</p> <p>Manned test results were obtained from studies that evaluated human factors interface and speech intelligibility in: (1) open ocean diving onboard a SDV; and (2) in the NEDU Ocean Simulation Facility.</p> <p>(Continued)</p>			
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT		21. ABSTRACT SECURITY CLASSIFICATION	
<input type="checkbox"/> UNCLASSIFIED/UNLIMITED <input checked="" type="checkbox"/> SAME AS RPT. <input type="checkbox"/> DTIC USERS		Unclassified	
22a. NAME OF RESPONSIBLE INDIVIDUAL NEDU Librarian	22b. TELEPHONE (Include Area Code) 904-230-3100	22c. OFFICE SYMBOL	

ITEM #19 (continued):

WOB results were favorable in most of the test conditions; however, simulated heavy work rates produced unacceptably high WOB levels in some test conditions. Also, some shortcomings of the FFM were revealed by the human factors and speech intelligibility studies. These findings preclude us from making an unlimited recommendation for approval at this time. Still the EX 24 FFM is recommended for approval within the limits listed in this report. Further manned testing is needed before these limits can be extended.

DTIC QUALITY INSPECTED 5

Accession For	
NTIS CRA&I	<input checked="checked" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By	
Distribution /	
Availability Codes	
Dist	Avail and/or Special
A-1	

GLOSSARY

CDS	Conventional Diving System, comprised of the EX 19 UBA and the EX 24 full face mask
CSS	Coastal Systems Station, Dahlgren Division, Naval Surface Warfare Center, Panama City, FL
Diluent	Breathable gas mixture, either HeO ₂ or N ₂ O ₂ , depending on the depth of dive, used in the MK 16 UBA during closed circuit operation to maintain breathing loop volume.
EBS II	Emergency Breathing System Type II
EOD	Explosive Ordnance Disposal
EX 24 FFM	AGA full face mask with CSS developed Switchover Block and communication microphone.
J/L	Joules per liter, unit of measure for "Work of Breathing" normalized for tidal volume
NEDU	Navy Experimental Diving Unit, Panama City, FL
OSF	Ocean Simulation Facility
RMV	Respiratory Minute Volume
SDV	SEAL Delivery Vehicle
Sofnolime 8 - 12	A Calcium Chloride CO ₂ absorbent, with particle sizes ranging from 1.0 to 2.5 mm
SPECWAR	Special Warfare
WOB	Work of Breathing; A computer derived estimate of total respiratory effort obtained when breathing a UBA with a mechanical breathing machine.

CONTENTS

	<u>Page No.</u>
INTRODUCTION	1
UNMANNED EVALUATION	
METHODS	1
RESULTS	2
CONCLUSIONS/RECOMMENDATIONS	2
MANNED EVALUATION	
HUMAN FACTORS EVALUATION	13
MICROPHONE EVALUATION	30
CONCLUSIONS	34
RECOMMENDATIONS	34
 APPENDIX A - Human Factors Evaluation Questionnaire EX 24 Full Face Mask	 A-1
APPENDIX B - Content Analysis of Written Comments of EX 24 FFM From the Evaluation Conducted in Puerto Rico	B-1
APPENDIX C - Content Analysis of Written Comments on EX 24 FFM From the Evaluation Conducted in NEDU OSF	C-1
APPENDIX D - Responses by Divers to Target Words During Speech Intelligibility Testing of the EX 24 FFM Microphone	D-1

ILLUSTRATIONS

<u>Figure No.</u>		<u>Page No.</u>
1	Comparison of CAT I open circuit air mode performance to Performance Goal Standard at 21.1°C (70°F)	6
2	Comparison of CAT I open circuit air mode performance to Performance Goal Standard at 4.4°C (40°F)	7
3	Comparison of CAT I open circuit air mode performance to Performance Goal Standard at -1.7°C (29°F)	8
4	Comparison of CAT IV closed circuit air mode performance to Performance Goal Standard at 21.1°C (70°F)	10
5	Comparison of CAT II open circuit air mode performance to Performance Goal Standard at -1.7°C (29°F)	11
6	Comparison of CAT IV closed circuit helium mode performance to Performance Goal Standard at -1.7°C (29°F)	12
7	Ability of mask seal to prevent leaks	14
8	Freedom of movement with mask counterweight	15
9	Ease of operating the purge button	16
10	Ease of connecting air whip	17
11	Ease of disconnecting air whip	18
12	Recommended optimum communications whip length	20
13	Ease of tightening mask straps	22
14	Visibility provided by mask	23
15	Ability of mask to remain unfogged	24
16	Overall comfort of the mask	25
17	Ability of mask seal to prevent leaks	26
18	Accessibility and operation of nose clearing device	27

<u>Figure No.</u>		<u>Page No.</u>
19	Ability to clear mask after flooding	28
20	Ability to understand speech with the communication system	29
21	Speech intelligibility results from EX 24 FFM microphone testing	33

TABLES

<u>Table No.</u>		<u>Page No.</u>
1	Unmanned EX 24 (WOB) Results	3
2	Recommended Operating Depth Limits for the EX 24	5

INTRODUCTION

The requirement for a full face mask with the ability to switch between closed circuit and open circuit modes has evolved from changes in diver mission profiles and enhanced concern for diver safety in the SPECWAR and EOD communities. The EX 24 Full Face Mask (FFM) has been developed to this end.

The EX 24 FFM is comprised of an AGA face mask with a switchover block developed by CSS. Included in the EX 24 is a new microphone for diver communication that can be used with existing communication systems onboard SDVs for SPECWAR, or through fiber optic communications/tether line in EOD applications. Additionally, the EX 24 incorporates VISTEX, an anti-fogging, scratch-resistant lens film (Film Specialties, Inc., Whitehouse, NJ).

The EX 24 was designed as part of the CDS to be used in conjunction with the EX 19 UBA. It can also be used with the MK 16 UBA, on which it was tested in the present series of experiments. The EX 24 allows operation in the closed/open circuit mode without doffing and donning different masks or T-bit mouthpieces. In the open circuit mode, air is supplied by a four foot whip that can interface with the Emergency Breathing System II (EBS II) umbilical, or by SDV boat air accessed by a quick-disconnect. In the closed circuit mode the EX 24 substitutes for the MK 16 T-bit mouthpiece.

UNMANNED EVALUATION

Unmanned evaluation of the EX 24 measured WOB levels and compared them to Performance Goal Standards¹, which represent optimal performance levels of UBAs in three category (CAT) configurations.

METHODS

Methods of testing the FFM are included in NEDU Test Plans^{2,3,4}. A breathing machine (Reimers Consultants, Falls Church, VA) provided sinusoidal breathing loops ranging from 18 to 90 RMV, to emulate varied diver work rates from resting to heavy work. Water temperatures varied from -1.7°C (29°F), per MK 16 MOD O UBA certification requirements, to 21.1°C (70°F). Test depths varied from surface to 91.9 msw (300 fsw)⁵. Open circuit testing was conducted to 46 msw (150 fsw); closed circuit testing was conducted using a 0.7 PO₂ nitrox mixture to 40 msw (130 fsw); a 0.7 PO₂ heliox mixture was used at depths exceeding 46 msw (150 fsw). Closed circuit testing was conducted using a fully operational MK 16 UBA using 8 -12 mesh (1.0 - 2.5 mm) CO₂ absorbent.

NEDU Test Plan 92-21 tested WOB in both open/closed circuit modes to a depth of 40 msw (130 fsw) on the MK 16 MOD O UBA.

NEDU Test Plan 92-35 tested WOB to 40 RMV in the open circuit mode on the EBS II to 46 msw (150 fsw) at one test temperature, -1.7°C (29°F).

NEDU Test Plan 92-36 tested WOB in the closed circuit mode on the MK 16 MOD O UBA at depths ranging from 70 msw (229 fsw) to 91.9 msw (300 fsw) at one test temperature, -1.7°C (29°F).

RESULTS

Results of WOB on the EX 24 are summarized in Table 1. The current performance goal for CAT I open circuit air SCUBA regulators in the ventilation range of 22.5 to 62.5 RMV is 1.4 J/L. For the purpose of this study, this performance goal is extended to 18, 75, and 90 RMV, as no standards for these RMV rates are currently available.

CONCLUSIONS/RECOMMENDATIONS

Based on the unmanned WOB results of the EX 24, we can recommend the EX 24 for Fleet use within the limits described below and summarized in Table 2.

It is important to note that established performance goals are not acceptance criteria for equipment approval and diving equipment that exceed these goals are not necessarily unsafe for diver use.

Figure 1 shows comparative WOB levels obtained from a category I (CAT I), open circuit air configuration in 21.1°C (70°F) water. Across all test depths, WOB levels remained equal to or better than Performance Goal levels. This was true even at 75 and 90 RMV, when compared to the 62.5 RMV WOB levels.

Figure 2 shows comparative WOB levels obtained from a CAT I, open circuit air configuration in 4.4°C (40°F) water. WOB levels remained equal to or better than Performance Goal levels only at the surface. At 10 msw, WOB levels were essentially identical to Performance Goal levels through 62.5 RMV, and slightly inferior at 75 and 90 RMV. At the remaining test depths, WOB levels were similar to Performance Goal levels through 40 RMV, and exceeded Performance Goal levels by up to 1 J/L at the higher RMV rates.

Figure 3 shows comparative WOB levels obtained from a CAT I, open circuit air configuration in -1.7°C (29°F) water. WOB levels remained equal to or better than Performance Goal levels only at the surface. At 10 msw, WOB levels were slightly inferior at 40 and 62.5 RMV. At the remaining test depths, WOB levels were similar to Performance Goal levels only at 22.5 RMV, and exceeded Performance Goal levels by up to 1.5 J/L at higher RMV rates.

TABLE 1
UNMANNED EX 24 (WOB) RESULTS

CAT I, Open Circuit Air, 21.1°C (70°F)

		RESPIRATORY MINUTE VOLUME				
		22.5	40	62.5	75	90
MSW	10	1.09	1.13	1.16	1.14	1.10
	20	0.93	0.99	0.90	1.12	1.30
	30	1.04	1.00	1.05	1.11	1.13
	40	1.06	1.10	1.17	1.36	--

CAT I, Open Circuit Air, 4.4°C (40°F)

		RESPIRATORY MINUTE VOLUME				
		22.5	40	62.5	75	90
MSW	0	0.98	1.21	1.02	0.90	0.82
	10	1.26	1.26	1.32	1.58	2.00
	20	1.18	1.33	1.83	2.07	2.24
	30	1.35	1.49	2.03	2.40	--
	40	1.41	1.65	2.32	--	--
	45	1.50	1.77	2.93	--	--

CAT I, Open Circuit Air, -1.7°C (29°F)

		RESPIRATORY MINUTE VOLUME				
		22.5	40	62.5	75	90
MSW	0	1.20	1.29	1.31	1.29	1.33
	10	--	1.34	1.54	--	--
	20	1.38	1.60	1.91	2.07	--
	30	1.49	1.75	2.16	2.91	--
	40	1.55	1.86	2.74	--	--
	46	1.58	1.91	3.59	--	--

TABLE 1 (CONTINUED)

CAT IV, Closed Circuit N_2O_2 , 4.4°C (70°F)

		RESPIRATORY MINUTE VOLUME				
		22.5	40	62.5	75	90
MSW	0	0.22	0.34	0.54	0.67	0.85
	10	0.27	0.48	0.83	1.09	1.40
	20	0.32	0.62	1.12	1.48	1.89
	30	0.37	0.73	1.39	1.84	2.44
	40	0.41	0.86	1.67	2.23	2.97

CAT II, Open Circuit Air, -1.7°C (29°F)

		RESPIRATORY MINUTE VOLUME		
		18	22.5	40
MSW	0	0.55	0.61	0.69
	10	1.12	1.06	1.19
	20	1.58	1.33	1.25
	30	1.40	1.32	1.30
	40	1.36	1.40	1.57
	45	1.58	1.44	1.37

CAT IV, Closed Circuit HeO_2 , -1.7°C (29°F)

		RESPIRATORY MINUTE VOLUME				
		22.5	40	62.5	75	90
MSW	70	0.35	0.62	1.92	1.43	1.91
	80	0.41	0.67	1.19	1.55	2.03
	91.9	0.39	0.68	1.23	1.61	2.14

TABLE 2

RECOMMENDED OPERATING DEPTH LIMITS FOR THE EX 24

CAT I OPEN CIRCUIT AIR

Temperature Range (°C/°F)	Maximum Work Load	Maximum Depth (msw / fsw)
21.7 / 70 and ABOVE	HEAVY	46 / 150
4.4 / 40 to 21.1 / 70 4.4 / 40 to 21.1 / 70	HEAVY MODERATE	20 / 65 46 / 150
-1.7 / 29 to 4.4 / 40 -1.7 / 29 to 4.4 / 40	HEAVY MODERATE	10 / 33 30 / 98

CAT II OPEN CIRCUIT AIR

Temperature Range (°C/°F)	Maximum Work Load	Maximum Depth (msw / fsw)
-1.7 / 29 and ABOVE	MODERATE	46 / 150

CAT IV CLOSED CIRCUIT N₂O₂

Temperature Range (°C/°F)	Maximum Work Load	Maximum Depth (msw / fsw)
-1.7 / 29 and ABOVE	HEAVY	46 / 150

CAT IV CLOSED CIRCUIT HeO₂

Temperature Range (°C/°F)	Maximum Work Load	Maximum Depth (msw / fsw)
-1.7 / 29 and ABOVE	HEAVY	91.9 / 300

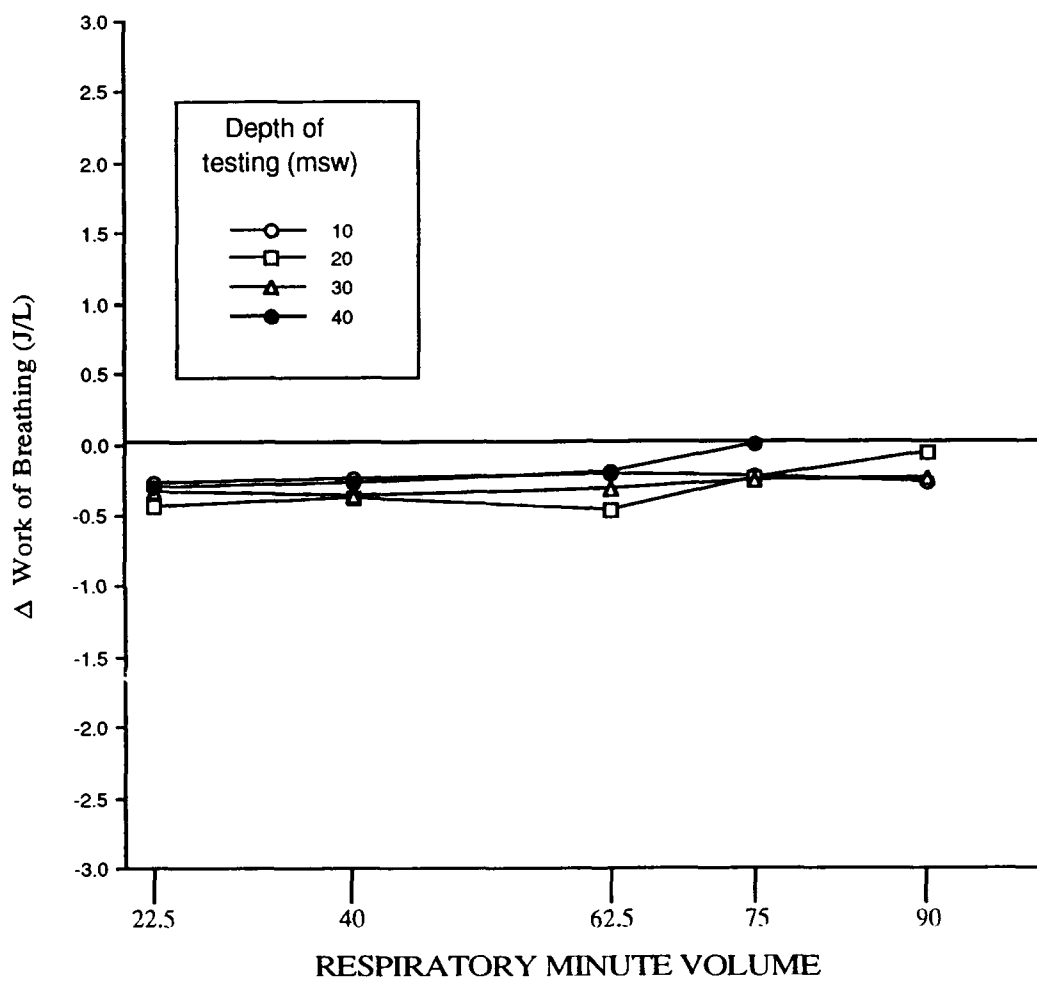


Figure 1. Comparison of CAT I open circuit air mode performance to Performance Goal Standard at 21.1°C (70°F)

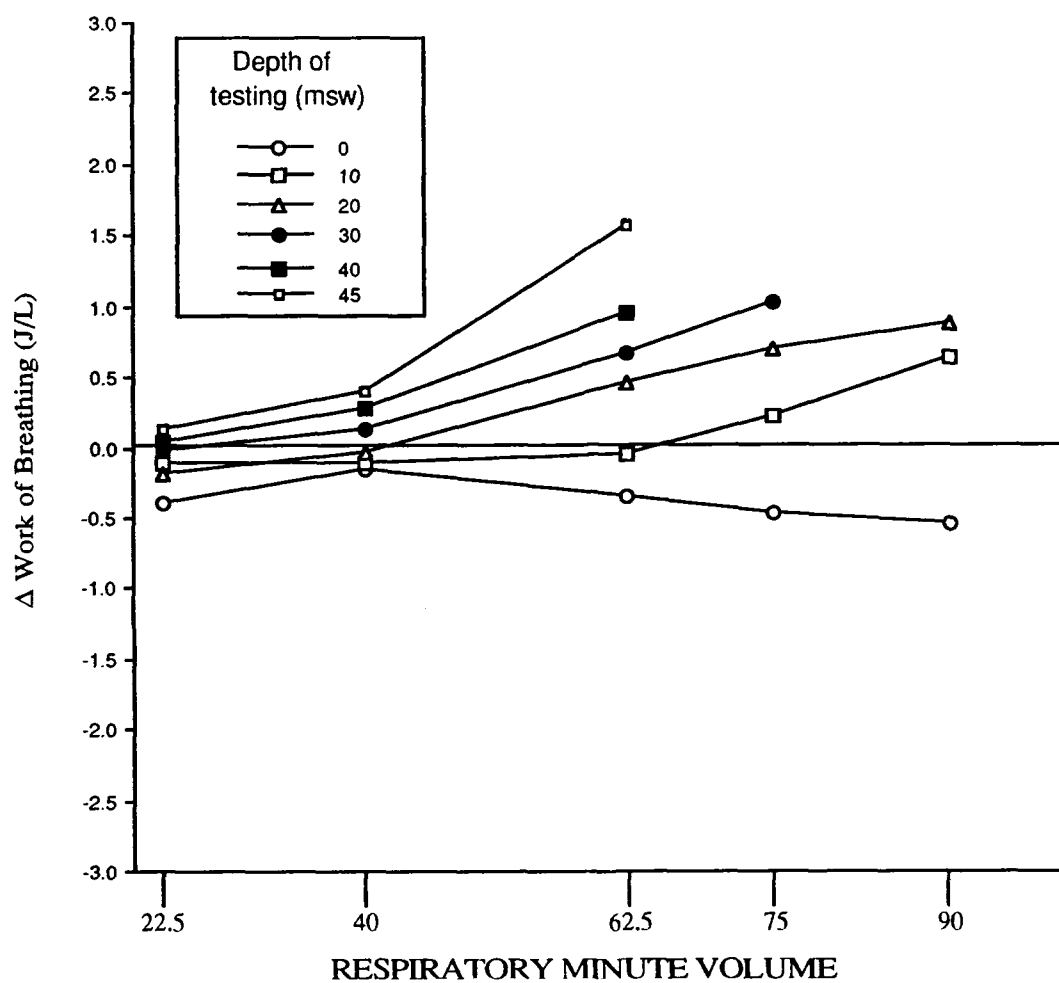


Figure 2. Comparison of CAT J open circuit air mode performance to Performance Goal Standard at 4.4°C (40°F)

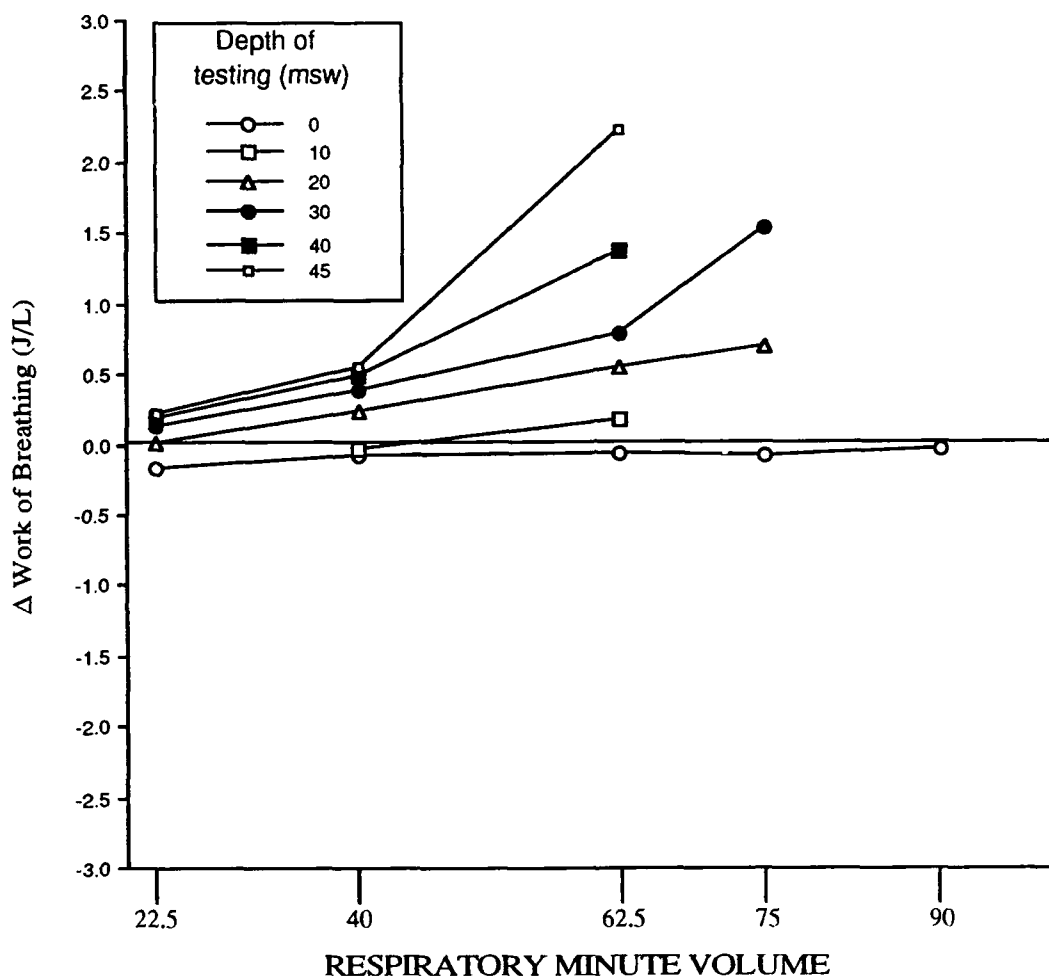


Figure 3. Comparison of CAT I open circuit air mode performance to Performance Goal Standard at -1.7°C (29°F)

Figure 4 shows comparative WOB levels obtained from a category IV (CAT IV), closed circuit air configuration in 21.1°C (70°F) water. WOB levels remained equal to or better than Performance Goal levels at the surface, and at 10 and 20 msw. Across all RMVs levels used, 30 msw WOB levels remained within .25 J/L of the Performance Goal levels; at 40 msw WOB levels remained within .5 J/L of the Performance Goal levels.

Figure 5 shows comparative WOB levels obtained from a category II (CAT II), open circuit air configuration in -1.7°C (29°F) water. Across all test depths, WOB levels remained equal to or better than Performance Goal levels. The 18 RMV data were compared to the 22.5 RMV WOB levels, as no standards for this RMV rate is currently available.

Figure 6 shows comparative WOB levels obtained from a CAT IV, closed circuit helium configuration in -1.7°C (29°F) water. Across all test depths, WOB levels remained equal or superior to Performance Goal levels, with the exception of 62.5 RMV results obtained at 70 msw (229 fsw), where obtained levels exceeded Performance Goal levels by approximately .5 J/L.

WOB levels of the EX 24 in the open circuit air mode that exceeded CAT I goals, but were equal or superior to CAT II goals, are recommended for approval. We do not believe that these performance levels will in any way be detrimental to the diver. Additionally, EX 24 WOB levels in the EBS II configuration were equal or superior to CAT II performance goals all the way to 46 msw (150 fsw). The CAT II goals do not extend beyond 40 msw (132 fsw).

Recommended Limits Based on Unmanned Testing

1. Closed circuit mode: to maximum depth and minimum temperature limits, i.e. 91.9 msw (300 fsw)/ -1.7°C (29°F).
2. Open circuit mode:
 - a. At 21.1°C (70°F) and above: any workload to maximum depth of 46 msw (150 fsw).
 - b. Between 4.4°C (40°F) and 21.1°C (70°F): at HEAVY workloads to a maximum depth of 20 msw (65 fsw); at MODERATE workloads to a maximum depth of 46 msw (150 fsw).
 - c. Between -1.7°C (29°F) and 4.4°C (40°F): HEAVY workloads to a maximum depth of 10 msw (33 fsw); at MODERATE workloads to a maximum depth of 30 msw (98 fsw).

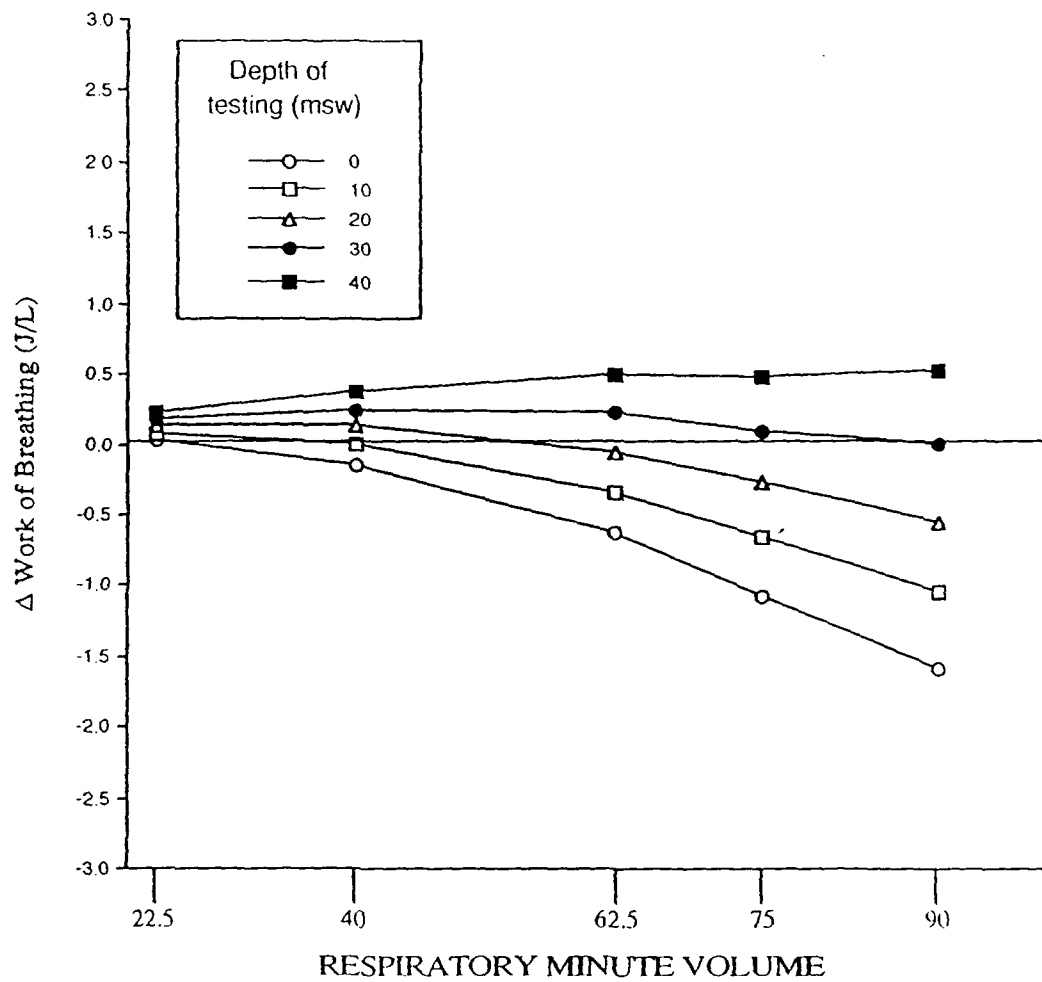


Figure 4. Comparison of CAT IV closed circuit air mode performance to Performance Goal Standard at 21.1°C (70°F)

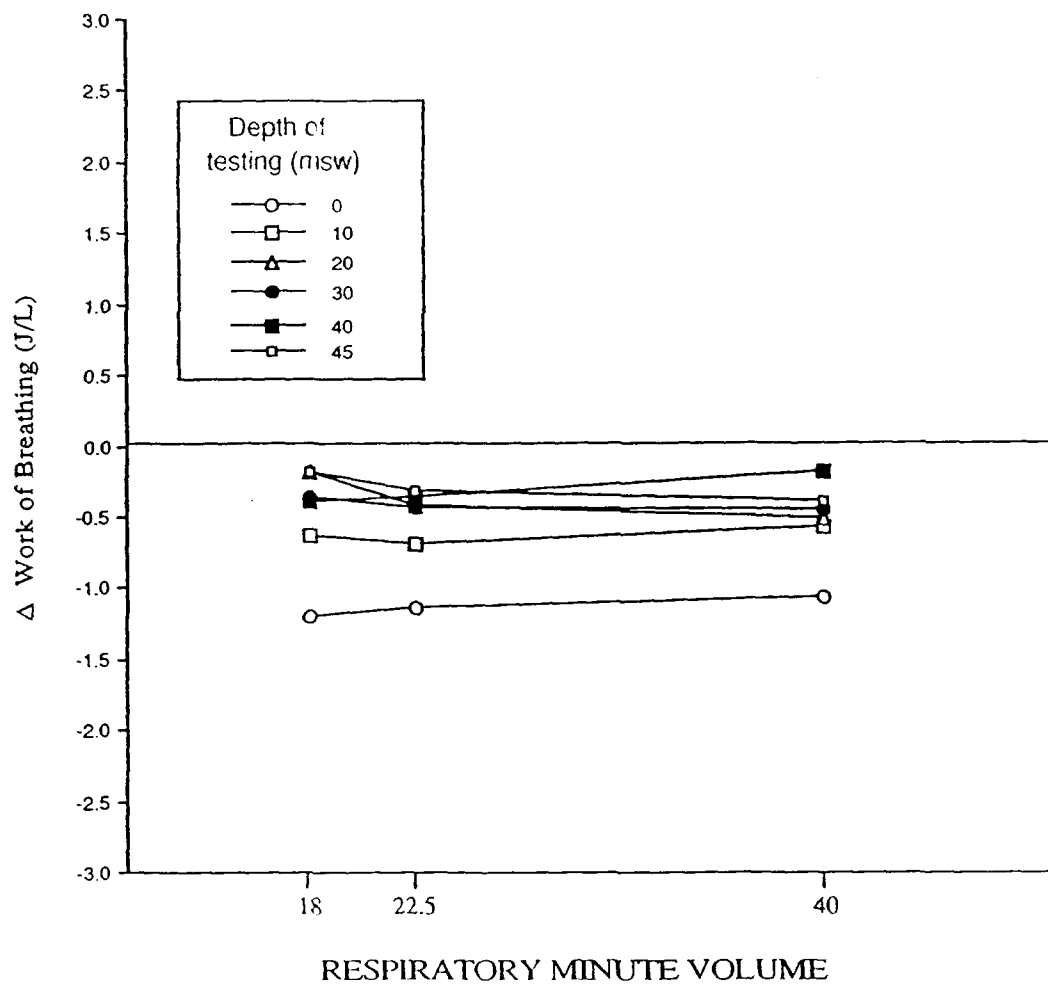


Figure 5. Comparison of CAT II open circuit air mode performance to Performance Goal Standard at -1.7°C (29°F)

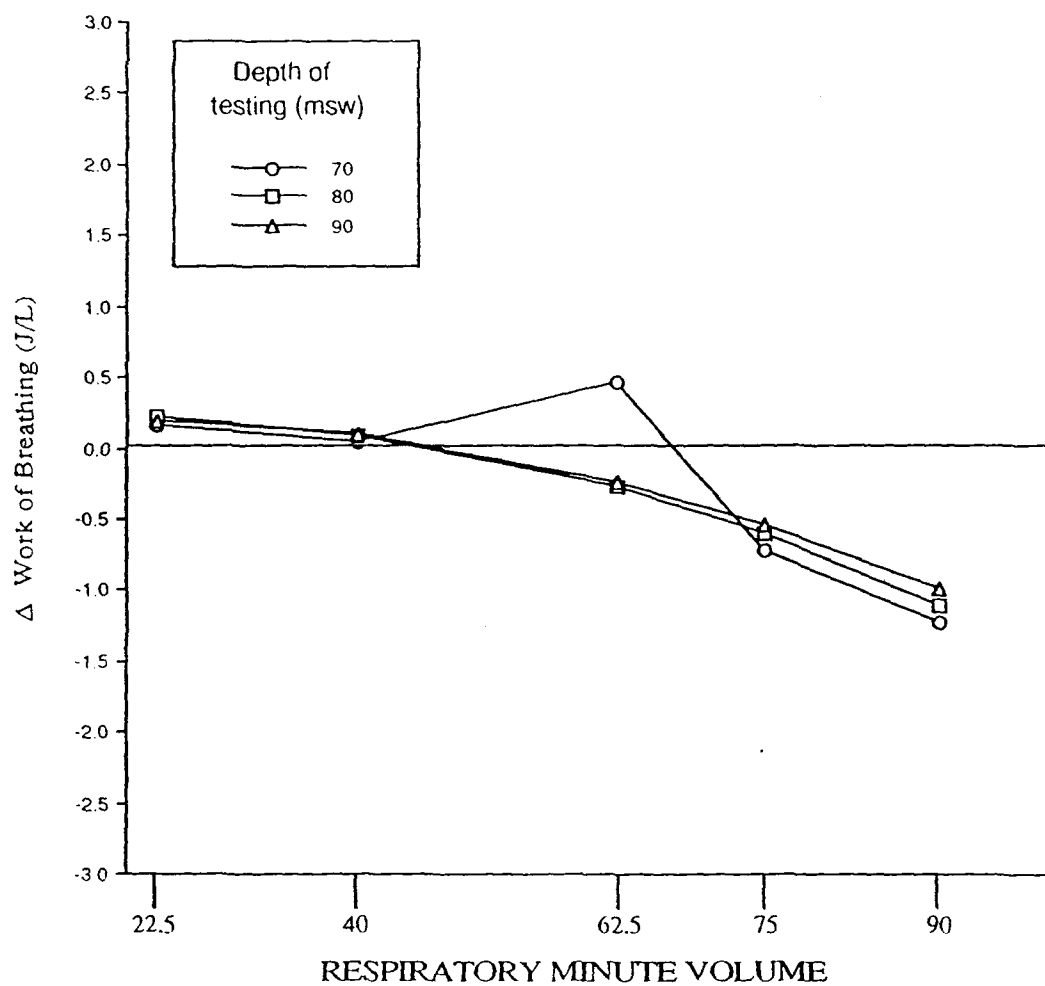


Figure 6. Comparison of CAT IV closed circuit helium mode performance to Performance Goal Standard at -1.7°C (29°F)

3. Open circuit mode: using air supplied by the EBS II (CAT II performance goals) to maximum depth and minimum temperature limits, i.e. 46 msw (150 fsw) and -1.7°C (29°F).

These limitations should remain in effect until further manned studies of the EX 24 in the above configurations are accomplished.

MANNED EVALUATION

Manned data were collected under two NEDU test plans^{6,7}. Testing evaluated Fit and Function of the FFM, as well as speech intelligibility of the microphone/communications system.

All diver subjects were military divers familiar with the operation of the MK 16 MOD O UBA and trained in FFM operation.

Manned studies were conducted using all design features of the EX 24, in as many environmental conditions available during these studies. The manned evaluation was broken up into two major areas: human factors evaluation of the FFM, systems interface, and speech intelligibility of the new microphone. Each diver subject completed a Human Factors questionnaire, Appendix A, following each experimental dive.

HUMAN FACTORS EVALUATION

Phase One - Puerto Rico

The first test⁶ evaluated the FFM Fit and Function at U.S. Naval Station Roosevelt Rhodes, Puerto Rico. Ten divers completed Human Factors questionnaires, Appendix A, secondary to SDV interface evaluation runs.

Results. In general, the diver-subjects from SDV Team FOUR rated most design features, comfort, and operation of the EX 24 FFM as adequate to excellent. In fact, for a majority of the questions, ratings were exclusively *good* or *excellent*. At the same time, there were five items on the questionnaire that elicited at least one unsatisfactory rating. Frequency distributions of diver-subject responses are graphically depicted in Figures 7-11.

One diver-subject rated ease of preventing leaks around the seal as *poor*, and two rated it as *not quite adequate* (Figure 7). One diver-subject rated freedom of movement with the counterweight as *poor* (Figure 8). One diver-subject rated ease of operating the purge button as *not quite adequate* (Figure 9). One diver-subject rated ease of connecting the air whip, as well as ease of disconnecting the air whip as *not quite adequate* (Figures 10 and 11).

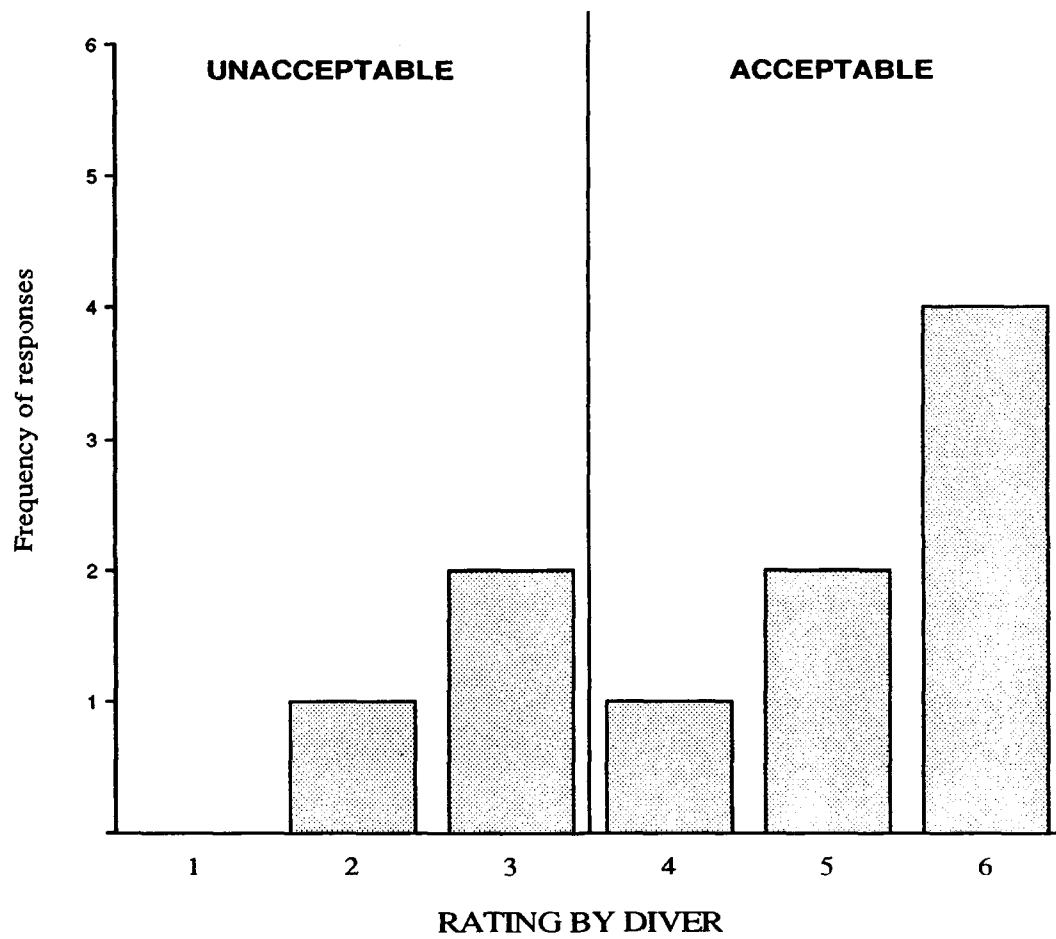


Figure 7. Ability of mask seal to prevent leaks

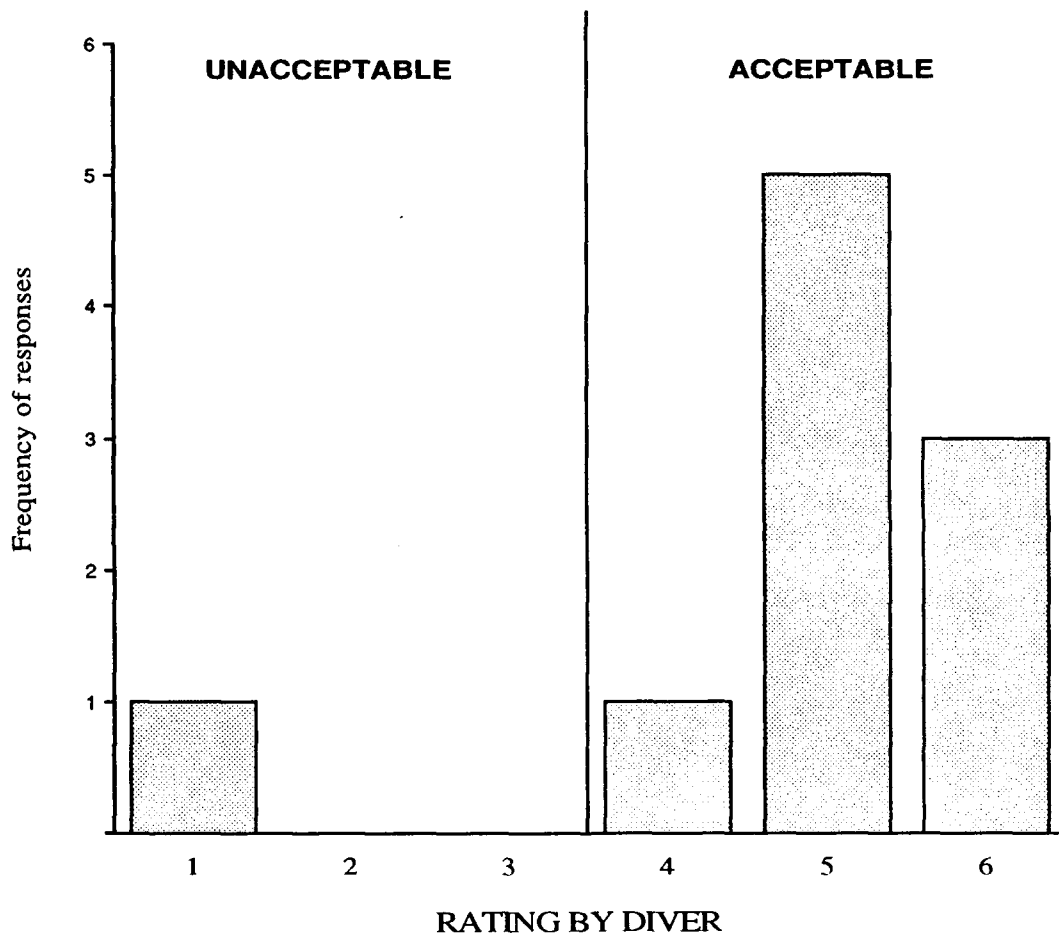


Figure 8. Freedom of movement with mask counterweight

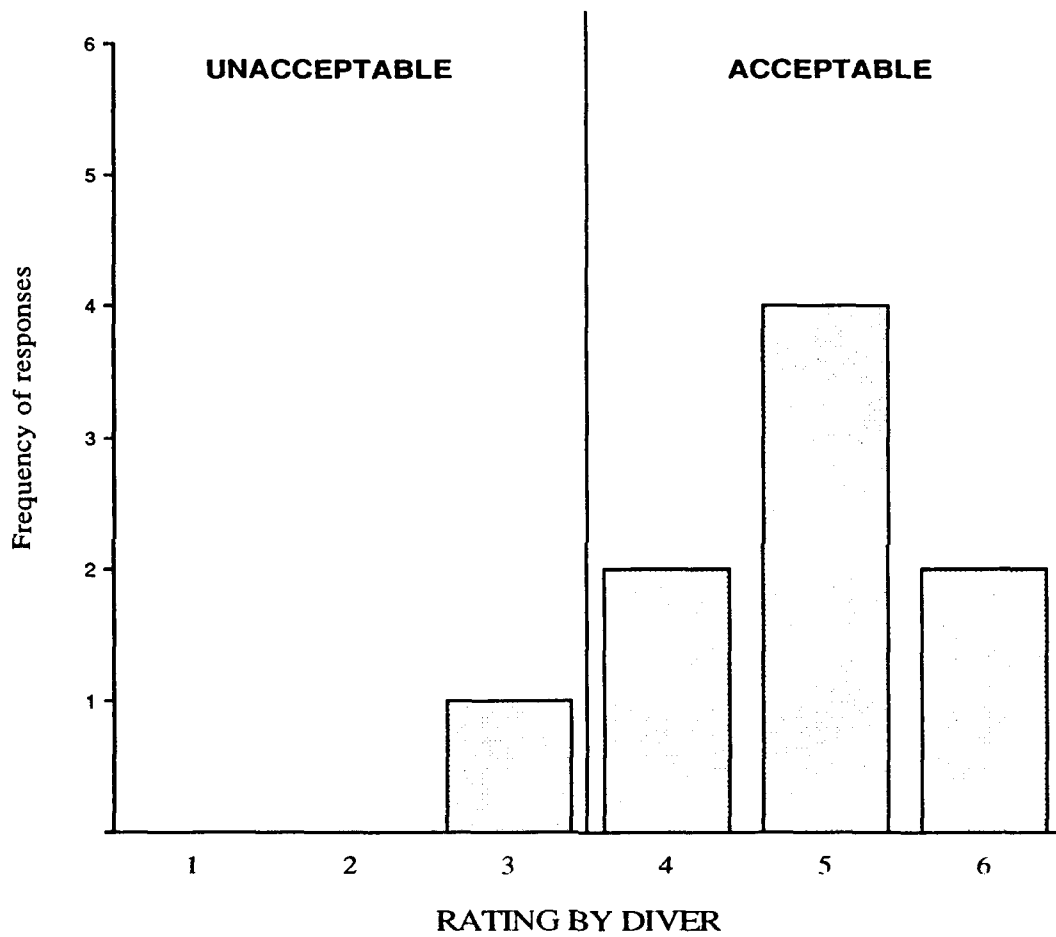


Figure 9. Ease of operating the purge button

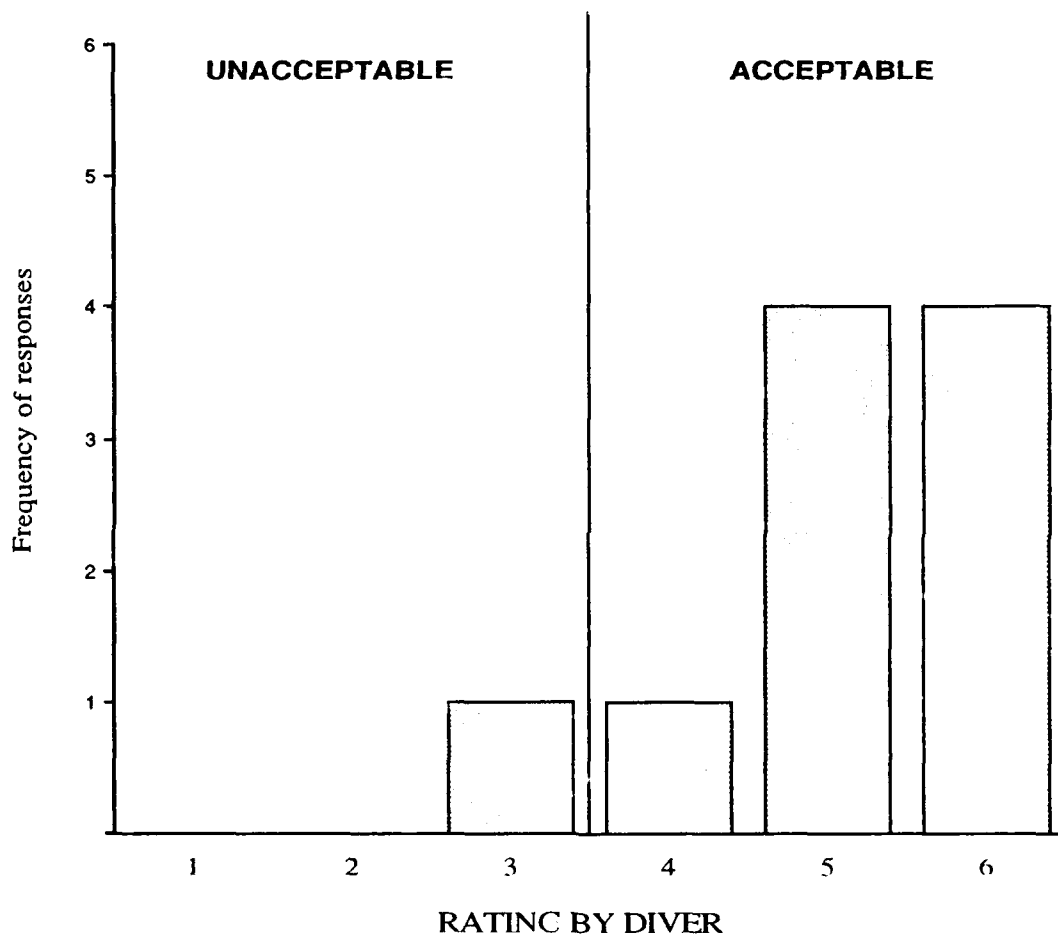


Figure 10. Ease of connecting air whip

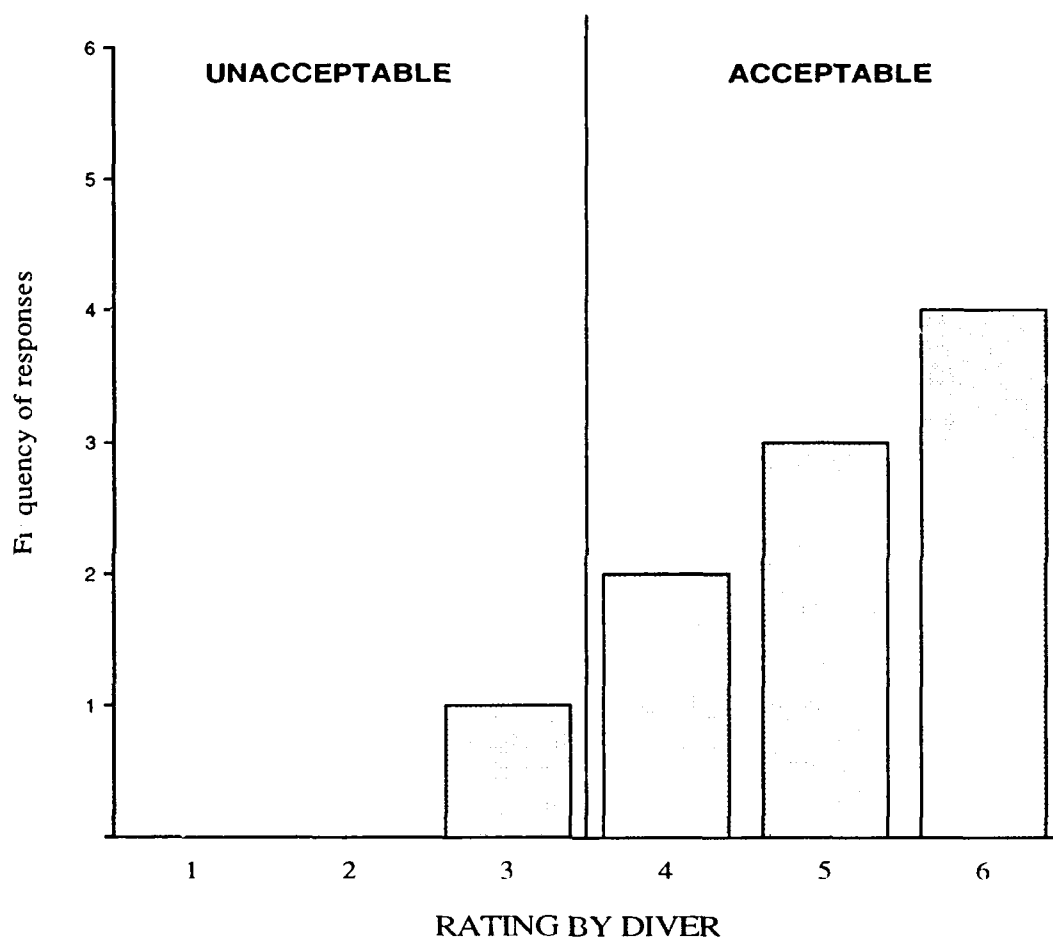


Figure 11. Ease of disconnecting air whip

In addition, content analysis of written answers was conducted; results are listed in Appendix B. Editorial latitude was taken to make complete sentences of sentence fragments, and to correct for blatant grammatical errors. The responses to each question are listed in a roughly ordinal fashion, from most positive to most negative. In addition to covering major concerns, the written answers also provided insight into some of the more incidental concerns of the diver-subjects.

Three points were brought up often concerning the fit and comfort of the mask. First, the complaint that the mask does not fit a narrow face, has been a problem with the AGA mask since it has been used in the Fleet. Anecdotal reports from divers with narrow faces suggest that lining the mask with surgical tubing provides the additional interface needed to provide a good seal. The second complaint brought up concerned restricted head movement due to the counterweight. Most often the difficulty was encountered while trying to look down. The third complaint, made by one diver, was that the temple straps slipped repeatedly.

The faceplate appeared to provide good visibility to the divers, although one diver-subject complained of slight fogging of the mask. Because these dives were conducted in relatively warm (i.e., 24.4°C (76°F)) water, the efficacy of the anti-fogging film was evaluated in cold water conditions during the second phase of manned testing (see below).

Connecting and disconnecting the air whip was rated as *unacceptable* by only one diver. However, written answers indicate that more than one diver encountered difficulty connecting and disconnecting the air whip. It is also important to note that in the present experiment the whip was tested only in warm water by diver-subjects wearing light diving gloves.

Other comments from several divers suggest that whip pressure is too high, since depressing the purge button resulted in a forceful blast of air to the diver. One diver also complained that the purge button could be depressed by the water current alone if he raised his head out of the SDV while underway. This appears to be due to the large surface area of the purge button.

One diver complained that the conms whip (Figure 12) could get in the way upon exiting the SDV.

Several divers complained about the display lights. The most common complaint was that the display lights are too bright. One diver did not like the mask-mounted display lights, and argued that displays should be mounted on the rig.

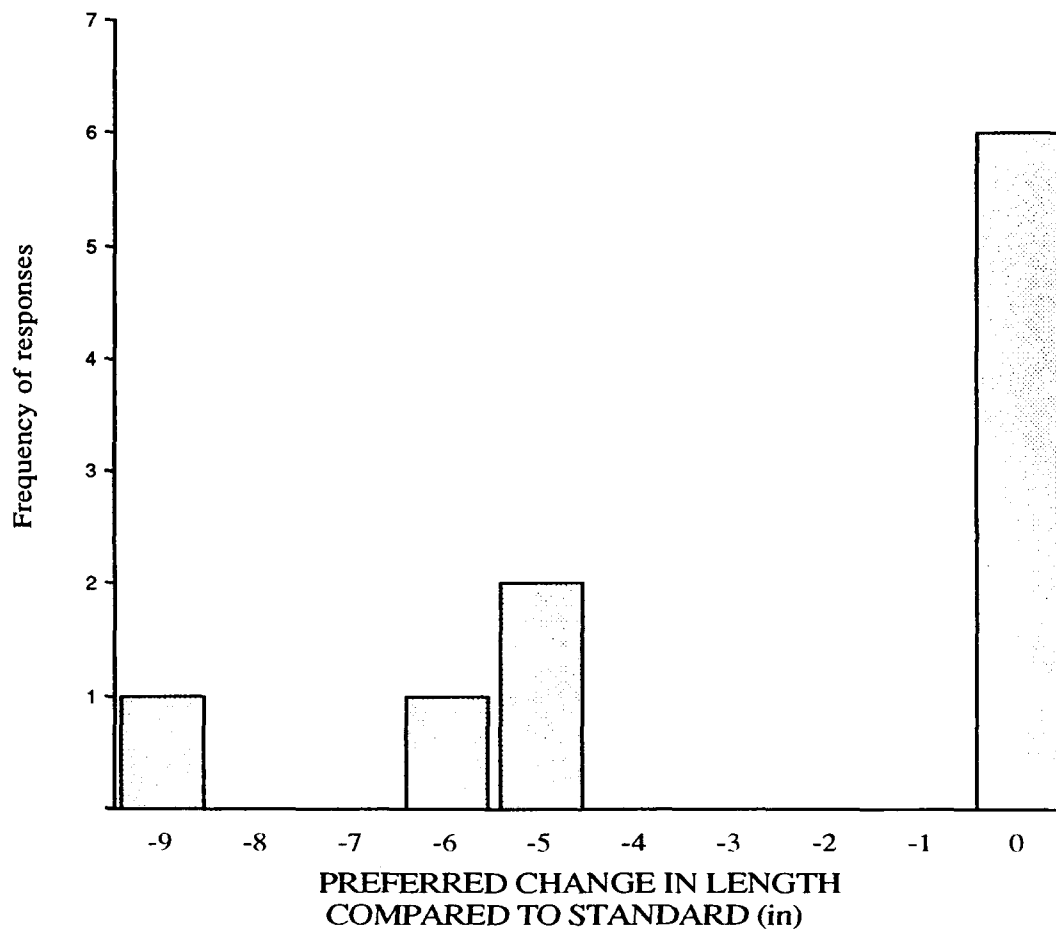


Figure 12. Recommended optimum communications whip length

The communication system received favorable comments in the closed-circuit mode, although one diver complained that the open circuit communication system was too noisy.

Phase Two - OSF

The second test⁷ evaluated the FFM Fit and Function in the NEDU OSF secondary to MK 16 UBA canister duration testing. Seven diver subjects filled out the Human Factors questionnaire, Appendix A, following the dives. At the same time, speech intelligibility of the FFM microphones was also evaluated using the Speech Perception in Noise (SPIN) test. Methods and results of communication system testing are discussed later in this report.

Results. In general, the diver-subjects rated most design features, comfort, and operation of the EX 24 FFM as adequate to excellent. In fact, for a majority of the questions, ratings were exclusively *good* or *excellent*. At the same time, there were eight items on the human factors questionnaire that elicited at least one unsatisfactory rating. Frequency distributions of diver-subject responses are graphically depicted in Figures 13-20.

One diver-subject rated the ease of tightening the mask straps as *not quite adequate* (Figure 13). One diver-subject rated the visibility provided by the mask as *not quite adequate* (Figure 14). Three diver-subjects rated the ability of the mask to remain unfogged as *not quite adequate*, and three diver-subjects rated it *poor* (Figure 15). Two diver-subjects rated the overall comfort of the mask as *poor* (Figure 16). Three diver-subjects rated the ability of the mask to prevent leaks as *not quite adequate*, and three diver-subjects rated it *poor* (Figure 17). One diver-subject rated the accessibility and operation of the nose clearing device as *not quite adequate*, and one diver-subject rated it *poor* (Figure 18). One diver-subject rated the ability to clear the mask after flooding as *poor* (Figure 19). One diver-subject rated the ability to understand speech with the communication system as *not quite adequate*, and one diver-subject rated it *poor* (Figure 20).

In addition, content analysis of written answers was conducted, and these are listed in Appendix C. Editorial latitude and ordinal arrangement of responses was again used in presenting these responses.

Several points were brought up often concerning the fit and comfort of the mask. First, the complaint that the mask does not fit a narrow face was reiterated by two divers. The second complaint brought up concerned the nose clearing device. Two divers listed this specifically, and the suggestion was made to make it of a softer material. Other points of discomfort listed by individual diver-subjects included the bridge of the nose, the temples, the forehead, and the jaw. The third complaint, made by one diver, was that the temple straps slipped

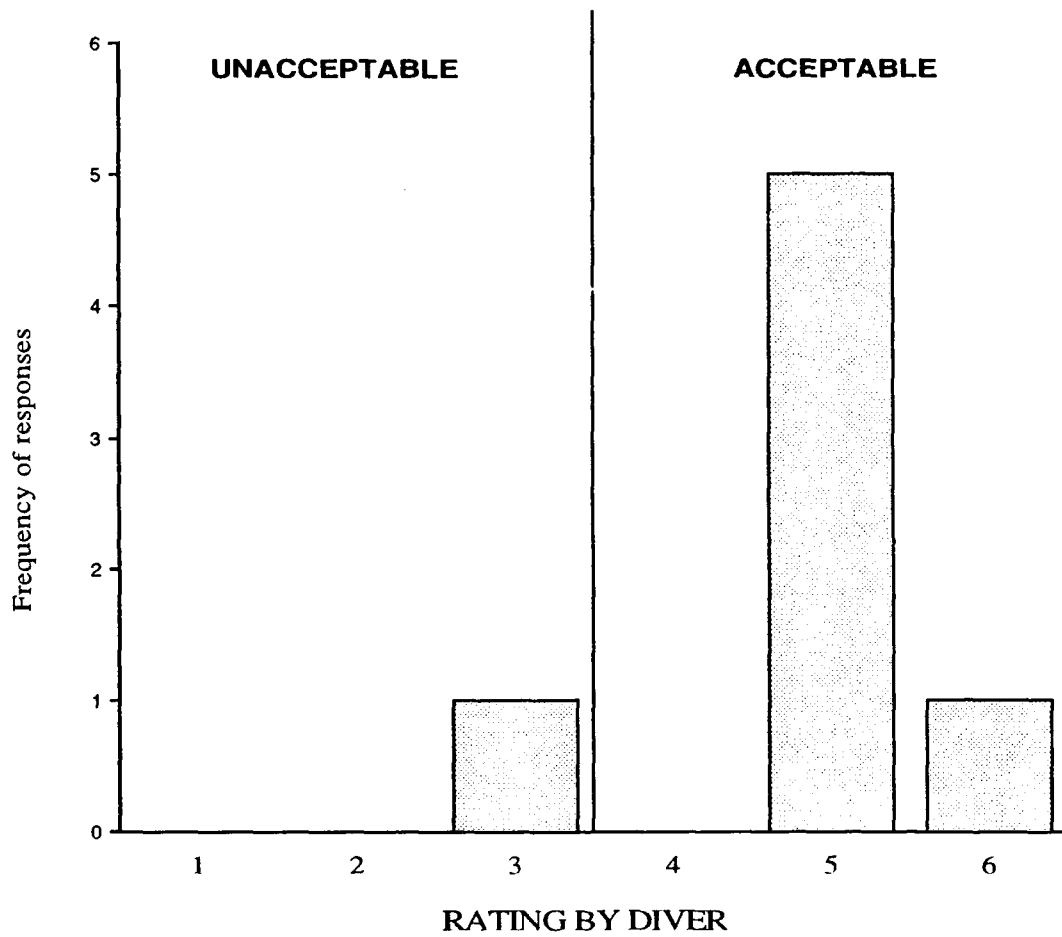


Figure 13. Ease of tightening mask straps

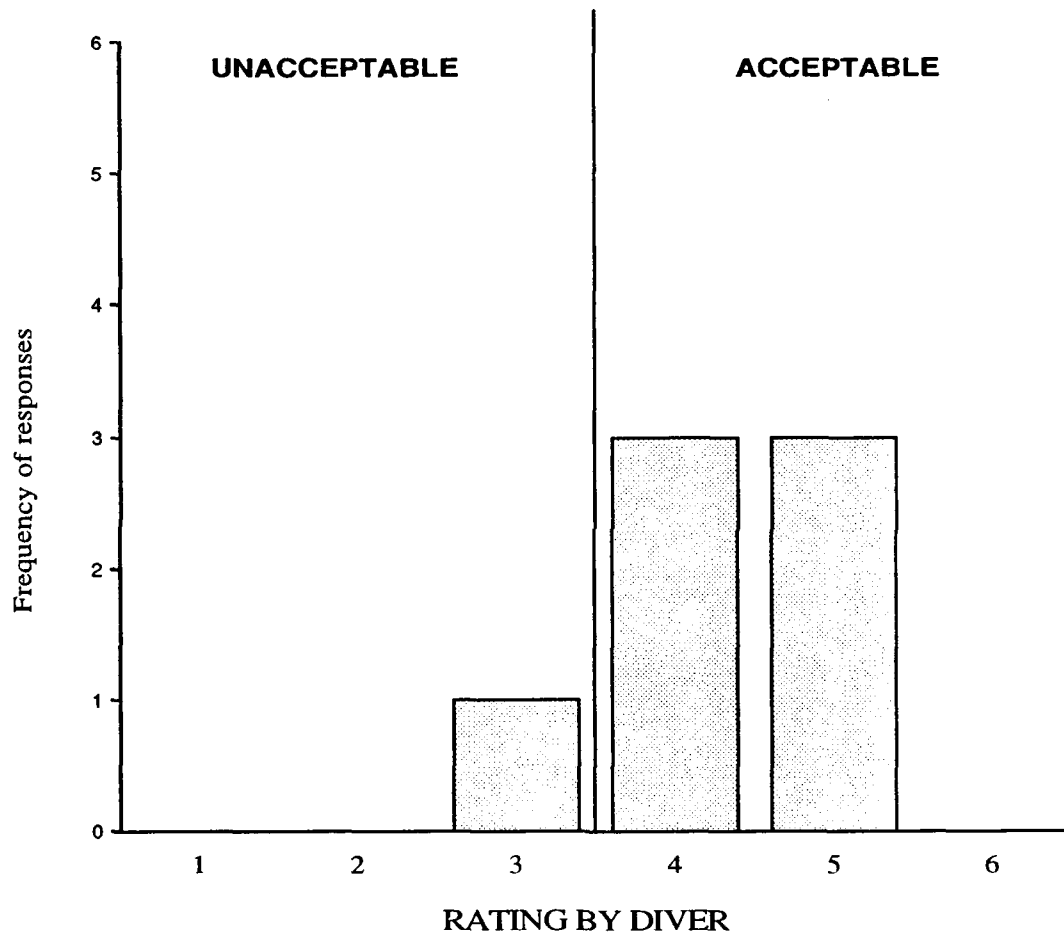


Figure 14. Visibility provided by mask

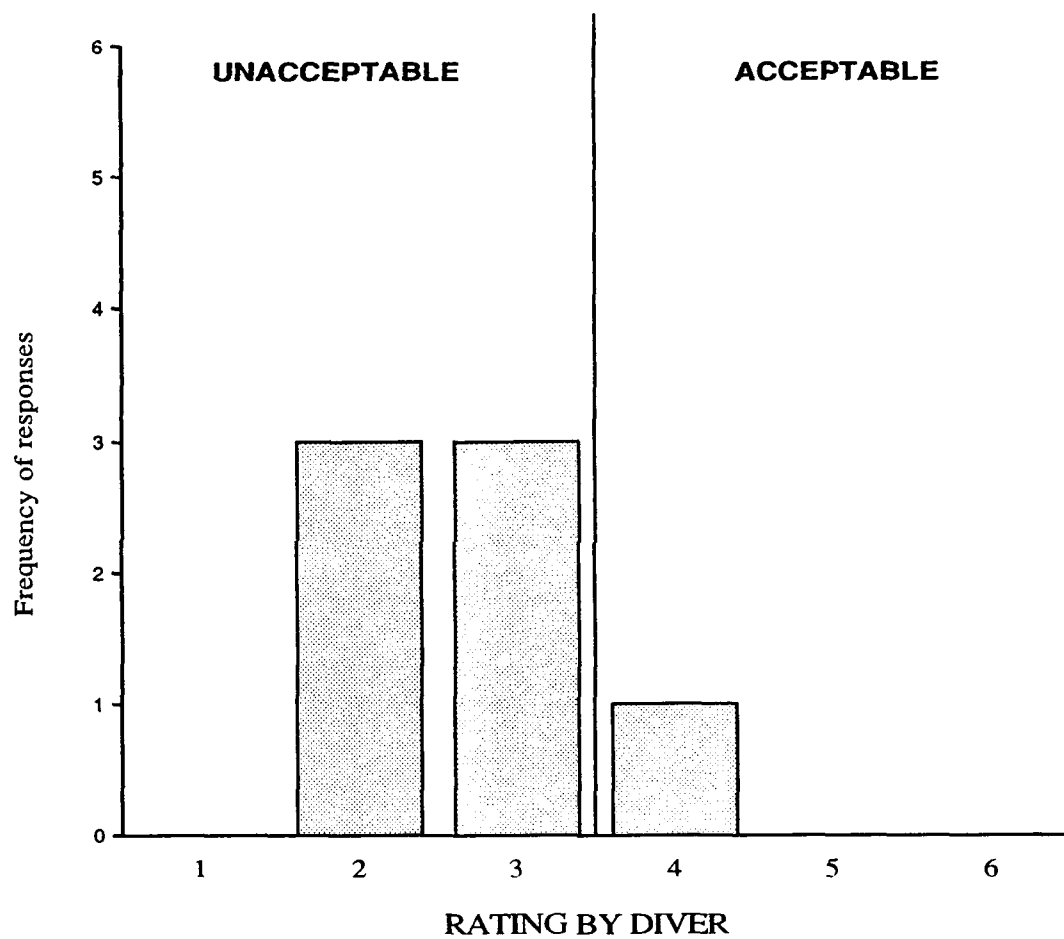


Figure 15. Ability of mask to remain unfogged

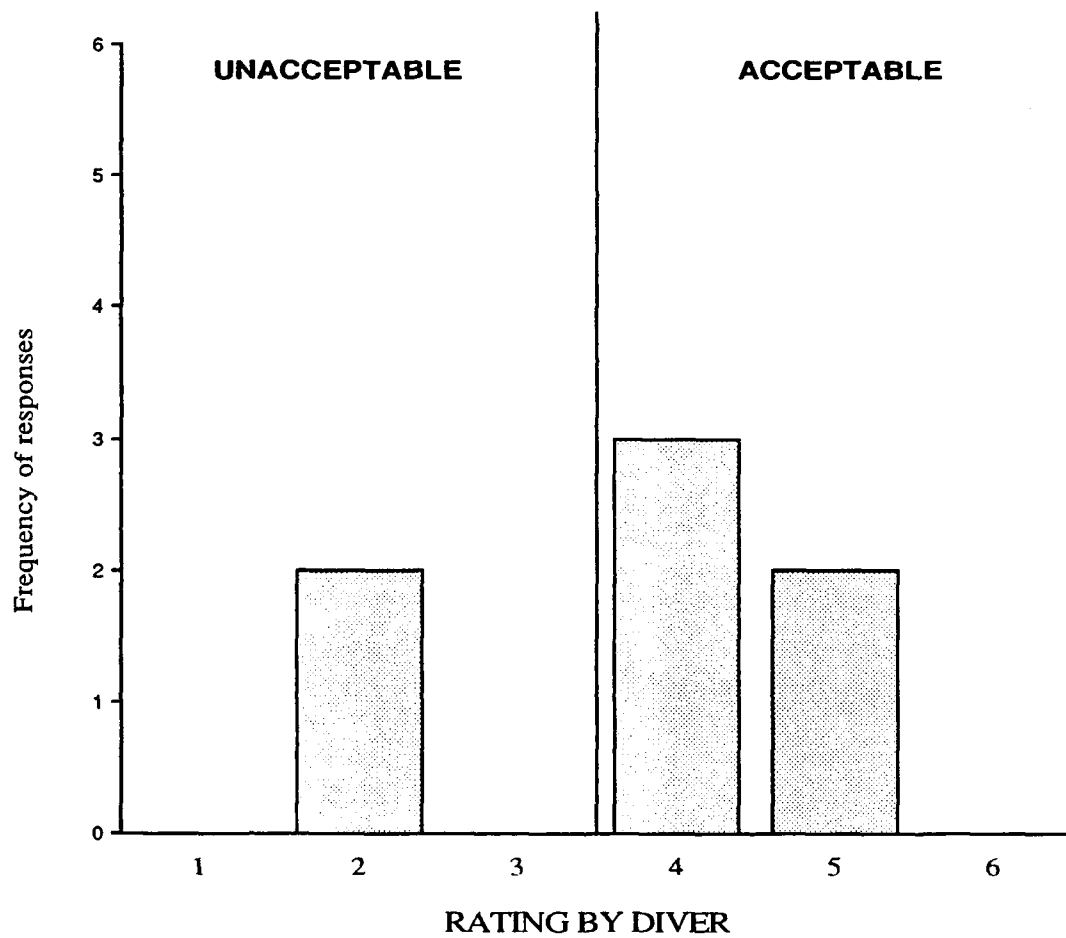


Figure 16. Overall comfort of the mask

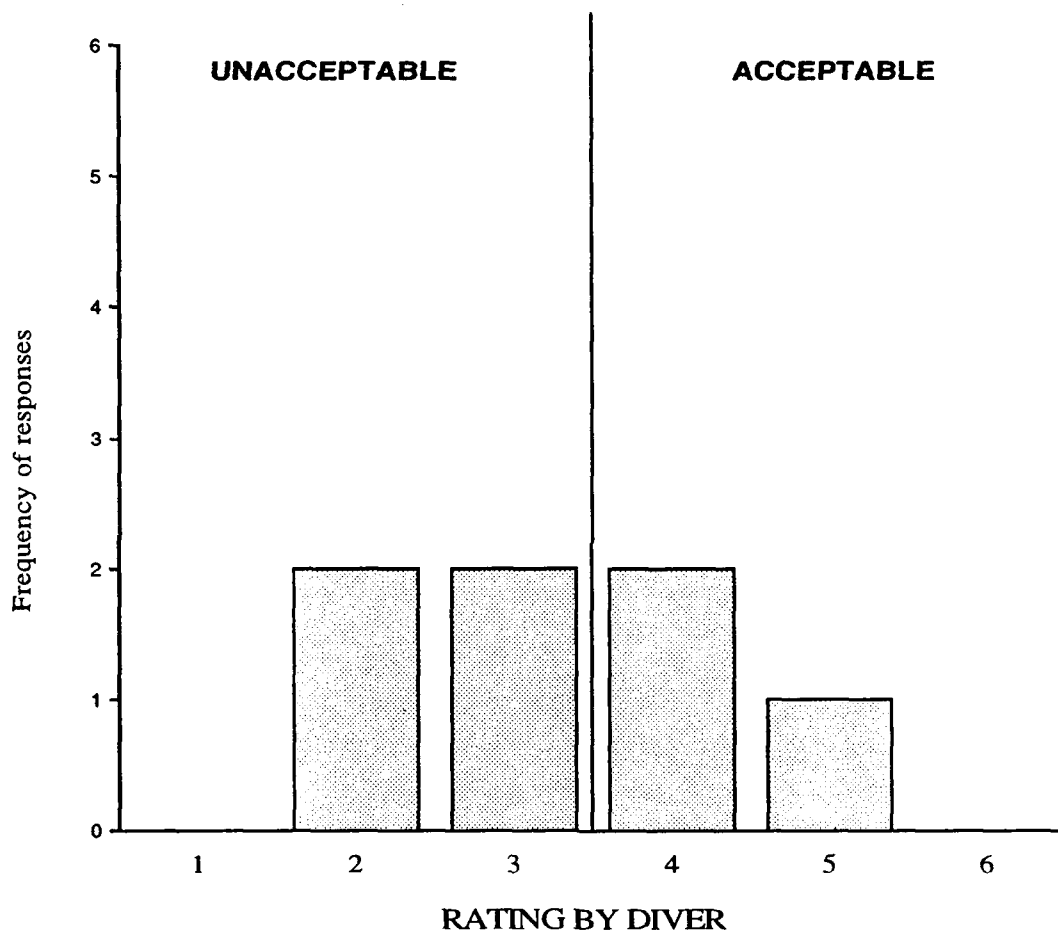


Figure 17. Ability of mask seal to prevent leaks

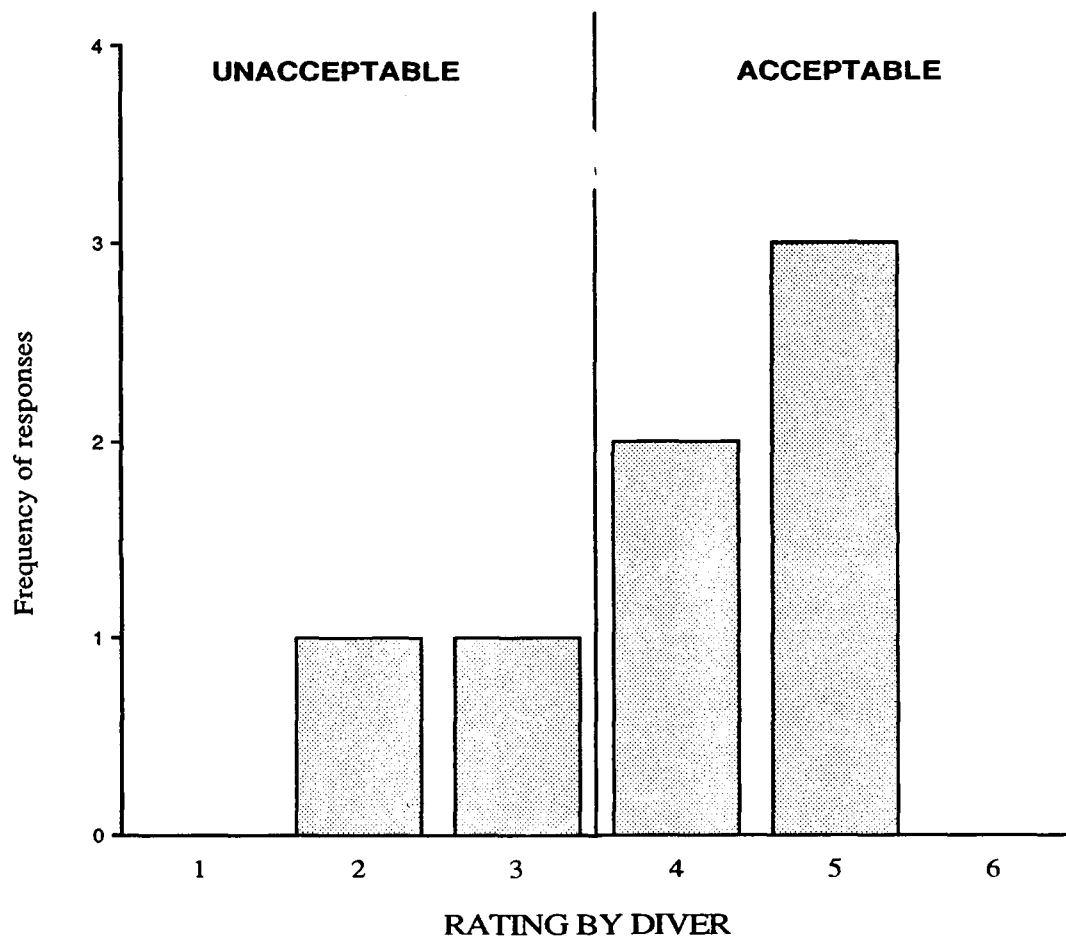


Figure 18. Accessibility and operation of nose clearing device

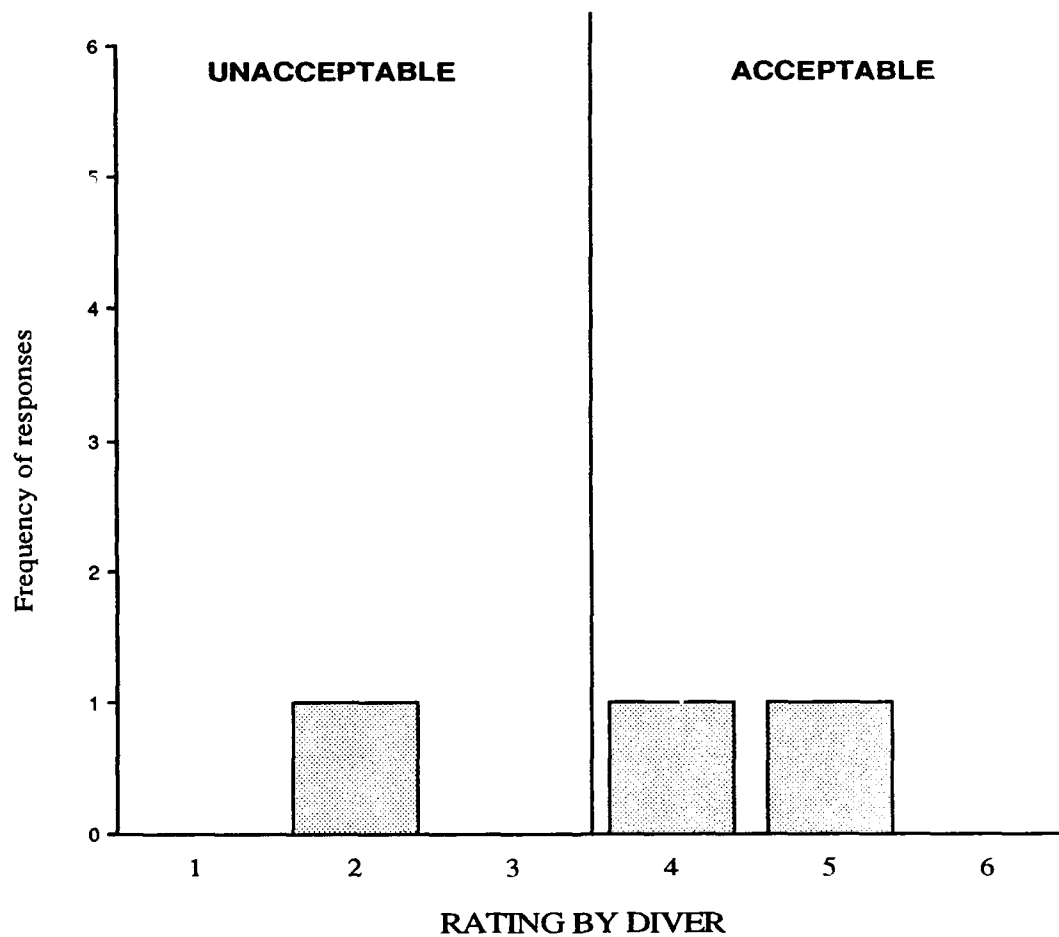


Figure 19. Ability to clear mask after flooding

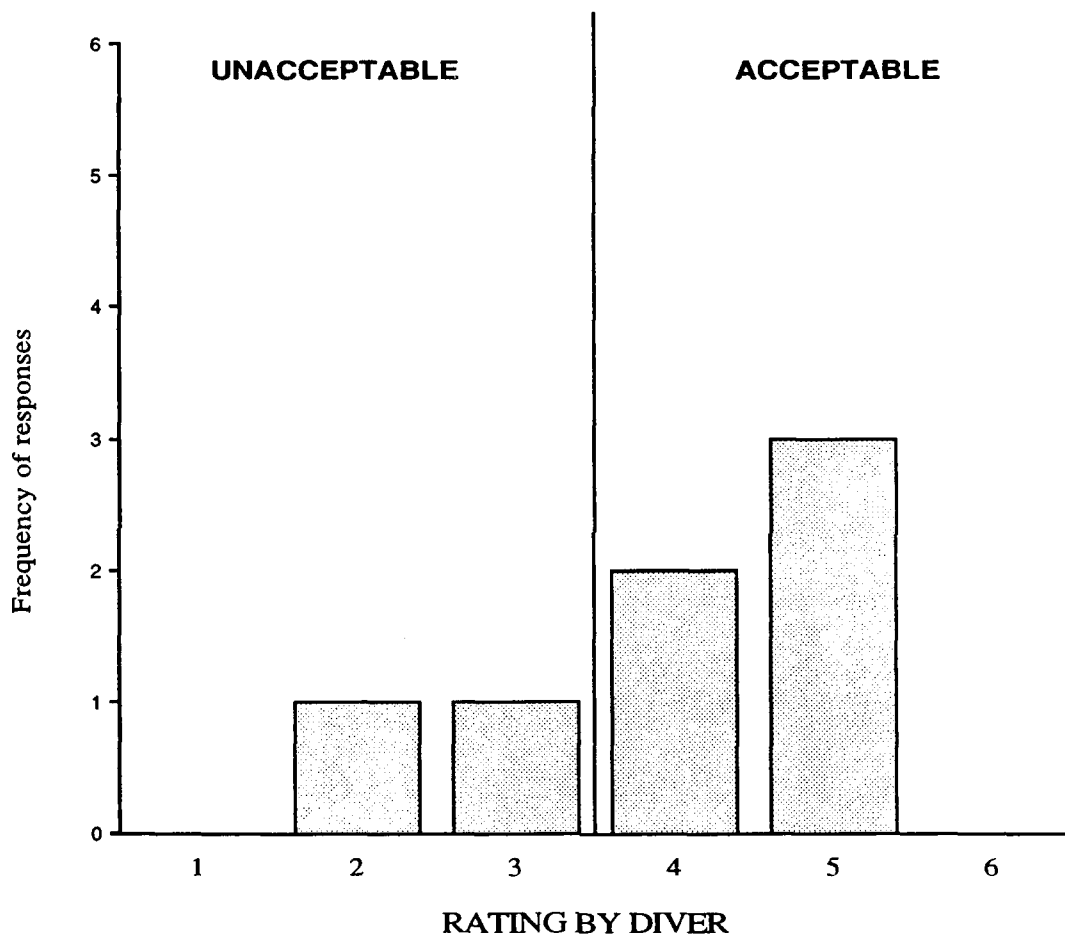


Figure 20. Ability to understand speech with the communication system

repeatedly, and should be configured like an O₂ built-in breathing system (BIBS) mask. The fourth complaint was the propensity for the faceplate to fog, particularly during exercise. This problem appears to be prominent among the diver-subjects responding during this part of the series because the water was much colder than in the study conducted in Puerto Rico (i.e., 24.4°C (76°F) versus 4.4°C (40°F)).

The communication system was considered inadequate in the helium mode by one diver, and in the open circuit mode by another diver. Results of empirical testing of the system are reported in the next section.

Conclusions of Human Factors Evaluation

The two most commonly-reported shortcomings of this FFM were the inability to establish a sound face seal and the propensity for the faceplate to fog. Another area of concern, while not reflected in the rating scales obtained from the Puerto Rico dive series, was connecting and disconnecting the air whip to boat air. Other concerns expressed by diver subjects appear to be bothersome, but not material to mission accomplishment. Face seal leaks have historically plagued divers with narrow faces using this FFM. It is unfortunate that the manufacturer, INTERSPIRO, does not make different size masks. Face mask fogging may be prevented by keeping the VISTEX clean.

MICROPHONE EVALUATION

Methods

The EX 24 FFM possesses a newly designed microphone, and the present series sought to determine whether this microphone provides sufficient speech intelligibility to divers. This communications system was tested in a nitrox breathing medium in closed- and open-circuit modes, as well as in a heliox medium in the closed-circuit mode. Initially, helium speech was going to be electronically unscrambled. However, due to technical problems with the unscrambler, testing was conducted using straight helium speech.

Speech intelligibility was accessed using the Speech Perception in Noise (SPIN) test, which was originally designed to assess hearing-impaired patients in a clinical setting. In the current series, SPIN word lists and response forms were printed on water/pressure-proof Kimdura® paper. The SPIN test employs sentences in which the target word is either contextually related to the sentence, e.g., "The dog ran away with the bone," or contextually unrelated to the sentence, e.g., "She was discussing the shirts."

Ten diver-subjects were tested with nitrox as the breathing medium. These tests were conducted under water at 6.1 msw (20 fsw) in the NEDU OSF. Seven diver-subjects were tested with helium as the breathing medium at the 30.5, 27.4, 24.4, and 21.3 msw (100, 90, 80, and 70 fsw) decompression stops made during the 91.4 msw (300 fsw) bounce dives conducted in this series. Among the latter group, one diver-subject was unable to read the word list without his eyeglasses, so only seven diver-subjects were tested. Shortly before testing began, all diver-subjects were provided with practice lists to practice sight reading. The practice lists were used to prevent the subjects from becoming familiar with the target words used on the regular test lists. The principal investigator reviewed the subjects' reading style and coached them in order to enhance the uniformity of reading style and word cadence.

Each diver subject read a different word list to his partner in the open- and closed-circuit configuration. The order of open- and closed-circuit testing was counterbalanced among test subject pairs. Testing of each diver pair with nitrox as the breathing medium was conducted as follows:

1. Red diver reads a word list to Green diver, who records his responses.
2. Green diver reads a word list to Red diver, who records his responses.
3. FFM configuration is changed.
4. Green diver reads a word list to Red diver, who records his responses.
5. Red diver reads a word list to Green diver, who records his responses.

Testing with heliox as the breathing medium was conducted as follows:

1. Red diver reads a word list to Green diver, who records his responses.
2. Green diver reads a word list to Red diver, who records his responses.

Statistical analysis of the speech intelligibility data obtained during nitrox testing were analyzed using a 2 X 2 within-subject analysis of variance (ANOVA), comparing two levels of rig configuration (open- and closed-circuit), and two

levels of target word presentation (contextual and non-contextual); simple main effects analyses were conducted post-hoc.

The data obtained during helium testing were analyzed using a paired Student t-test, comparing contextual and non-contextual target word presentation. For statistical purposes, the significance criterion for data analysis was set at $P < .05$.

Results

While being tested with a nitrox breathing medium (see Figure 21), speech intelligibility ranged from 68.4% in the open-circuit/non-contextual sentence condition to 97.6% in the closed-circuit/contextual sentence condition. Overall closed-circuit speech intelligibility levels were reliably higher than open-circuit levels, during both contextual and non-contextual word presentation. Also, contextually-presented target words were reliably more intelligible than target words presented non-contextually in the open-circuit mode; no difference between presentation mode was found during closed-circuit testing.

Speech intelligibility was markedly lower when the microphone was tested in a helium breathing medium (see Figure 21). Intelligibility levels were 20% using non-contextual sentences, and 32% using contextual sentences, a reliable difference.

Conclusions of Microphone Studies

The EX 24 microphone provided adequate levels of speech intelligibility among diver-subjects tested in a nitrox environment, in both the open- and closed-circuit modes. The open circuit configuration reliably reduced speech intelligibility levels, as did the non-contextual presentation of target words to divers on open-circuit. Still, in an operational setting the content of diver verbal communication would likely entail the task at hand, and thus spoken utterances would remain within a contextual framework, enhancing intelligibility. During open-circuit testing, several divers complained that the noise experienced during exhalation made it impossible to understand the sentences.

Interpretation of the helium speech intelligibility data is more problematic. First, testing was conducted at a relatively shallow depth, where straight helium speech is normally less degraded than at deeper depths; evaluation of the system at deeper depths may yield even poorer results. Second, the low levels of speech intelligibility obtained in the present series may or may not be due to shortcomings of the microphone itself. Anecdotally, divers' speech was clearly intelligible to personnel in the control room during testing. Therefore, one source of degraded intelligibility may have been from using a bone conduction speaker.

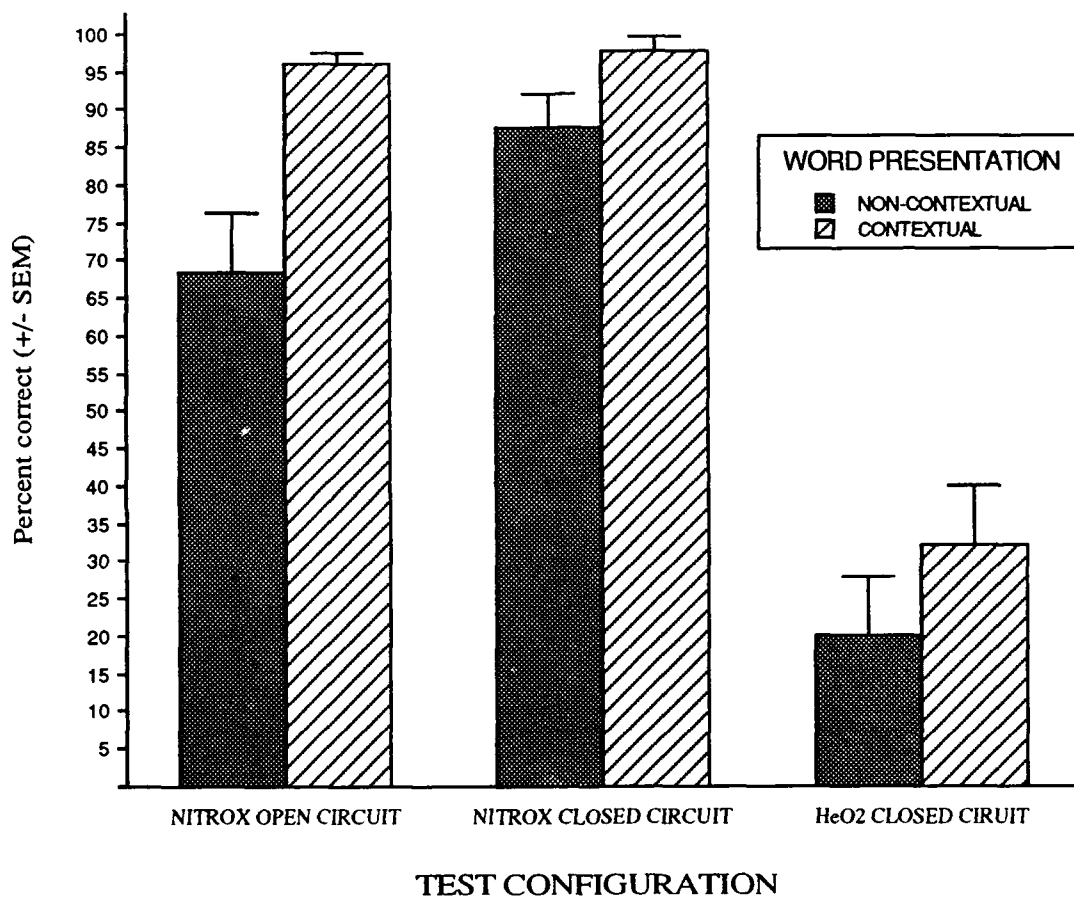


Figure 21. Speech intelligibility results from EX 24 FFM microphone testing

Third, while the test lists represent a standardized format for speech presentation, they do not realistically simulate the speech that a working diver would expect to hear. When the divers spoke to each other before and after intelligibility testing, they exhibited a higher level of comprehension than test results suggest. Finally, EOD divers currently use line pull signals during operations; adding a communications system, even with marginal effectiveness, would likely enhance diver safety. Therefore, it may be advantageous to develop a more task-oriented speech testing procedure for divers, in order to adequately evaluate speech intelligibility of communications systems. Incorrect SPIN responses are listed in Appendix D.

CONCLUSIONS

The EX 24 FFM provided WOB levels that we consider acceptable for Fleet operations within the limits noted in Table 2. It is possible that the EX 24 FFM can be safely used at depths beyond those given in Table 2. However, extended limits would have to be man tested before receiving an NEDU recommendation.

The human factors evaluation exposed some short comings of the mask. Most of the complaints made about the FFM apply as well to the AGA FFM, which has been used in the fleet for years. Therefore, the complaints about the EX 24 do not appear likely to endanger diver safety or mission accomplishment. The added feature of the switchover block markedly increases diver safety. The microphone provided adequate communications in a nitrox medium in both open and closed circuit modes, while heliox speech intelligibility was markedly degraded. However, this appears due to the bone conductors in the speaker system rather than the microphone itself.

RECOMMENDATIONS

The two major concerns we have recommending this mask from a human factors standpoint are: 1) The difficulty obtaining a sound face seal encountered by many divers; and 2) the persistent fogging of the mask in cold water, in spite of the VISTEX anti-fogging film. Other, less critical shortcomings of the mask included: 1) ease of connecting the air whip; 2) ease of disconnecting the air whip; 3) the overall comfort of the mask; 4) accessibility and operation of the nose clearing device; and propensity for the purge button being activated by water current.

At the present time, we recommend approval of the EX 24 FFM for use with the MK 16 MOD 0 UBA with the following conditions: 1) For those divers who prefer to, allow the use of surgical tubing to enhance the fit of the AGA FFM. This practice is currently used in the fleet; and 2) The VISTEX anti-fogging film in the mask needs to be thoroughly cleaned prior to each dive, as this enhances its

ability to keep the mask clear. We recommend that this practice be included in the FFM pre-dive procedures. It also appears that a slightly stiffer purge button spring is desirable to prevent accidental activation. At the same time, we feel that the large size of the purge button is advantageous for operation with gloved hands.

The EX 24 FFM should be man tested in cold water (1-2° C) during air breathing at 46 msw (150 fsw). Until that time, use of the FFM should be limited as described in Table 2.

REFERENCES

1. J. R. Middleton and E. D. Thalmann, *Standardized NEDU Unmanned UBA Test Procedures and Performance Goals*, NEDU TR 3-81, Navy Experimental Diving Unit, July 1991.
2. *Test and Evaluation of the Draeger Full Face Mask (FFM) with the CSS Switchover Block on a MK 16 UBA (Unmanned)*, NEDU Test Plan 92-21 (Limited Distribution), Navy Experimental Diving Unit, May 1992.
3. *Test and Evaluation of the Emergency Breathing System Type II (Unmanned)*, NEDU Test Plan 92-35 (Limited Distribution), Navy Experimental Diving Unit, August 1992.
4. *Test and Evaluation of the MK 16 MOD O with Coastal Systems Station Full Face Mask (Unmanned)*, NEDU Test Plan 92-36 (Limited Distribution), Navy Experimental Diving Unit, August 1992.
5. *Standard Practice for Use of the International System of Units (SI)*, Document E380-91a, American Society for Testing and Materials, Philadelphia, PA, 1991.
6. *EX 24 FFM Interface with SDV and Swimmer (Manned)*, NEDU Test Plan 93-03 (Limited Distribution), Navy Experimental Diving Unit, March 1993.
7. *EX 19/MK 16 UBA Bounce Dive Series (Manned)*, NEDU Protocol 92-50 (Limited Distribution), Navy Experimental Diving Unit, December 1992.

APPENDIX A

HUMAN FACTORS EVALUATION QUESTIONNAIRE EX 24 FULL FACE MASK

Name of diver _____ Date of dive: _____
Number of dives in past 3 years using full face mask, e.g., MK 20? _____
Dive profile: Depth (fsw) _____ Duration (min) _____ Water Temp (°F) _____
Brief description of dive _____

Describe dress used for dive _____
How was rig used during the dive?
Open circuit only _____ Closed circuit only _____ Open and closed circuit _____
Type of gloves worn during dive? _____

RATING SYSTEM:

1=extremely poor	3=not quite adequate	5=good
2=poor	4=adequate	6=excellent

EASE OF DON AND DOFF:

1. How would you **rate** the ease of getting the harness over your head with the mask in place? _____
2. How would you **rate** the ease of tightening the straps? _____
3. How would you **rate** the ease of loosening the straps and doffing the mask? _____

OVERALL COMFORT OF MASK:

4. How would you **rate** the visibility provided by the mask? _____
5. Were there any especially distracting blind spots/visibility problems (yes/no)? _____
If yes, describe: _____
6. How would you **rate** the ability of the faceplate to remain unfogged? _____
7. How would you **rate** the overall comfort of the mask as it fit your face? _____
8. How would you **rate** the ease of preventing gas leaks around the face seal? _____
9. How would you **rate** the mask's comfort in terms of overall buoyancy? _____
10. How would you **rate** the buoyancy of the mask, considering the counterweight? _____
11. How would you **rate** freedom of movement, considering the counterweight? _____
12. How would you **rate** balance of the mask, considering the counterweight? _____

13. List specific points of face/mask contact that were uncomfortable _____
14. If there was any discomfort wearing the mask, how long were you wearing the mask before the discomfort became apparent? _____
15. What specific activities can you identify that made the mask especially uncomfortable? _____

USE AND OPERATION OF MASK:

16. How would you rate the ease of breathing the mask while at rest? _____
17. How would you rate the ease of breathing the mask at moderate work levels? _____
18. How would you rate the ease of breathing the mask at heavy work levels? _____
19. How would you rate the ability of the faceplate to remain unfogged? _____
20. How would you rate the accessibility and operation of the nose clearing device? _____
21. How would you rate the location and configuration of the purge button? _____
22. How would you rate the accessibility and operation of the purge button? _____
23. How would you rate the ease of clearing the mask after it was flooded? _____
24. How would you rate the location and configuration of the switchover block? _____
25. How would you rate the ease of operating the switchover block? _____
26. How would you rate the location and configuration of the air whip quick release? _____
27. How would you rate the ease of connecting air whip quick release while wearing gloves? _____
28. How would you rate the ease of disconnecting air whip quick release while wearing gloves? _____
29. How would you rate the ease of connecting the comms whip while wearing gloves? _____
30. How would you rate the length of the comms whip for you while riding on the SDV?
 ___ Too short (by ___ inches) ___ Too long (by ___ inches) Appropriate length _____
31. How would you rate the ease of disconnecting the comms whip while wearing gloves? _____
32. How would you rate the ease of speaking while wearing the mask? _____
33. How would you rate the understandability of other divers wearing the mask? _____

Please provide any additional comments about the mask that you think are important, including suggestions you feel would enhance its performance/safety: _____

APPENDIX B

CONTENT ANALYSIS OF WRITTEN COMMENTS ON EX 24 FFM FROM THE EVALUATION CONDUCTED IN PUERTO RICO

MASK FIT AND COMFORT:

- Mask fit my face perfectly and I have yet to find an AGA mask that fits.
- Overall, the old AGAs don't even compare, especially in the area of comfort.
- Overall, the mask was awesome. I feel the open circuit is an excellent safety feature. However, [the configuration tested with the counterweight limited the downward motion of the head slightly. The mask is a definite breakthrough and I hope to use it in the teams soon. Also, as long as MK 15s are in use I think the mask should be tailored to fit them.
- When on open circuit I could really feel the air roll up the side of my face and head. I think it would be very distracting over a long open circuit dive. This mask, the way it is, is 100 times better than what we now have. These are just minor comments.
- Temple straps slipped regularly. Counterweight prohibits free head movement. The mask pulled to the right (i.e., the air hose side).
- Riding on SDV, experienced restricted head movement.
- The mask became uncomfortable while trying to look down.
- Need a mask for a narrow face.
- Need to manufacture a mask for narrow faces to create a better seal.

POINTS OF DISCOMFORT IN MASK:

- Nose P

FACEPLATE VISIBILITY:

- Anti fog film an outstanding high point.
- The face plate fogged slightly

USE AND OPERATION OF MASK:

AIR WHIP:

LENGTH:

- The air whip is a perfect length for pilot/navigator to work in the crew compartment.
- Shorten O/C lead.

CONNECTING/DISCONNECTING:

- The quick disconnect needs work.
- Air whip would be tough with thick gloves. Whip female doesn't always seat...free flows (quick disconnect).

WHIP PRESSURE:

- Maybe lower pressure in O/C whip. When you purge the face mask comes slightly off my face. No big deal.
- Open circuit air pressure is too high.

OPERATION OF PURGE BUTTON:

- Purge is very sensitive—high force.
- The purge needs work.
- The O/C purge button is very big and blows air in the navigator's face if he puts his head out of the SDV while under way.
- Mask still retained some water after clearing.

SWITCHOVER BLOCK:

- Switchout block an outstanding high point.

COMMUNICATIONS:

CLARITY OF SYSTEM:

- Great Comms!
- Comms an outstanding high point.
- The microphone is 400% better than the MK 20.
- Open circuit comms are difficult to hear.

COMMS WHIP:

- Comms whip becomes a hazard when the navigator/pilot exits the SDV for activity under the target.

DISPLAY LIGHTS:

- I did not like the primary display light mounted on the mask, but I do like all the accessories/displays that are attached to the rig vice the person.
- The primary display is too bright for the pilot/navigator.
- For combat purposes, the primary display is not tactical.

APPENDIX C

CONTENT ANALYSIS OF WRITTEN COMMENTS ON EX 24 FFM FROM THE EVALUATION CONDUCTED IN NEDU OSF

MASK FIT AND COMFORT:

- The mask was comfortable and easy to wear.
- Modify straps like O₂ BIBS.
- Nose clearing device should be made of a softer or different material.
- Mask is uncomfortable for long dives.
- The mask was too large and had to be very tight so that it wouldn't leak. More sizes are needed for different face sizes, so the mask does not have to be so tight.
- If I raised my head from looking down the mask would overpressurize and I would get a severe gas leak all around the face seal even with the straps cinched down.

POINTS OF DISCOMFORT IN MASK:

- Nose clearing device (2 divers)
- Oral-nasal on the bridge of the nose
- Straps
- Temples
- Forehead
- Jaw

FACEPLATE VISIBILITY:

- Fogging produced poor visibility in the mask (4 divers).
- Needs a better anti-fogging lens

SWITCHOVER BLOCK:

- Switchover was a little stiff to operate but not too hard to operate.

COMMUNICATIONS:

CLARITY OF SYSTEM:

- Breathing helium you could not understand the other diver.
- On open circuit you had to adjust your breathing to hear.

APPENDIX D

RESPONSES BY DIVERS TO TARGET WORDS DURING SPEECH INTELLIGIBILITY TESTING OF THE EX 24 FFM MICROPHONE

CLOSED CIRCUIT NITROX:

	<u>TARGET WORD</u>	<u>SUBJECT'S RESPONSE</u>	<u>CONTEXTUAL OR NON-CONTEXTUAL</u>
<u>WORD LIST 1:</u>	GROWL DRAIN	GROUND DREAM	NON-CONTEXTUAL NON-CONTEXTUAL
<u>WORD LIST 3:</u>	GRIN TACK GEESE BREAD CAP BEEF CLUE MAT DENT FROGS	RIM CAT GREESE TREAD CAT SPEAK CREW MAP VENT CLUMPS	CONTEXTUAL CONTEXTUAL NON-CONTEXTUAL NON-CONTEXTUAL NON-CONTEXTUAL CONTEXTUAL NON-CONTEXTUAL CONTEXTUAL NON-CONTEXTUAL CONTEXTUAL
<u>WORD LIST 5:</u>	RUG SLOT FUN DART CRATES BEADS	BREAD SWAT FUND DARK CREATES DEEDS	NON-CONTEXTUAL NON-CONTEXTUAL NON-CONTEXTUAL NON-CONTEXTUAL NON-CONTEXTUAL NON-CONTEXTUAL
<u>WORD LIST 6:</u>	GANG	GAME	NON-CONTEXTUAL
<u>WORD LIST 8:</u>	JUNK	JERK	NON-CONTEXTUAL

OPEN CIRCUIT NITROX:

WORD LIST 1:

OX	US	CONTEXTUAL
CROOK	TRUCK	NON-CONTEXTUAL
FOAM	FUN	NON-CONTEXTUAL
SKIRT	SHARK	NON-CONTEXTUAL
CLIFF	FOOT	NON-CONTEXTUAL
GROWL	DRILL	NON-CONTEXTUAL
POND	FUN	NON-CONTEXTUAL
TOLL	TOW	NON-CONTEXTUAL
PILE	TOWEL	NON-CONTEXTUAL

WORD LIST 3:

DIME	DOLLAR	CONTEXTUAL
STRAP	SCRAP	NON-CONTEXTUAL
PORK	PORT	NON-CONTEXTUAL
POLE	POTEM	NON-CONTEXTUAL

WORD LIST 4:

BROOM	-----	NON-CONTEXTUAL
RIM	-----	NON-CONTEXTUAL
CROWN	CROWD	NON-CONTEXTUAL
BEEF	-----	NON-CONTEXTUAL
FIST	FISH	NON-CONTEXTUAL
SCREEN	SCREAM	NON-CONTEXTUAL
MAST	MASK	NON-CONTEXTUAL
BOWL	BALL	NON-CONTEXTUAL

WORD LIST 5:

GRIN	GRIND	NON-CONTEXTUAL
AID	AGE	NON-CONTEXTUAL
BROOM	BRIM	NON-CONTEXTUAL
SCARE	STAIR	NON-CONTEXTUAL
KICK	CAKE	NON-CONTEXTUAL
TACK	TAIR	NON-CONTEXTUAL
BEEF	BRIEF	NON-CONTEXTUAL
MAST	MASK	NON-CONTEXTUAL

WORD LIST 6:

GANG	GAME	NON-CONTEXTUAL
MINK	-----	NON-CONTEXTUAL
THIEF	FEE	NON-CONTEXTUAL
SLOT	-----	CONTEXTUAL

SCREAM	STREAM	NON-CONTEXTUAL
SHED	-----	NON-CONTEXTUAL
CLIP	-----	NON-CONTEXTUAL
CLERK	CLUB	NON-CONTEXTUAL
SPY	-----	NON-CONTEXTUAL
WRIST	RISK	NON-CONTEXTUAL
SAND	-----	CONTEXTUAL

WORD LIST 7:

THORNS	FORMS	NON-CONTEXTUAL
--------	-------	----------------

CLOSED CIRCUIT HELIUM:

WORD LIST 1:

SPCON	SKIP	CONTEXTUAL
CRACK	CLAP	NON-CONTEXTUAL
RAG	-----	NON-CONTEXTUAL
OX	LIPS	CONTEXTUAL
STEAM	SPOT	CONTEXTUAL
LUNGS	-----	NON-CONTEXTUAL
CROOK	COOK	NON-CONTEXTUAL
COIN	-----	CONTEXTUAL
DRUG	-----	CONTEXTUAL
FOAM	BEFORE	NON-CONTEXTUAL
SKIRT	SPOT	NON-CONTEXTUAL
LAP	-----	CONTEXTUAL
BONE	BARN	CONTEXTUAL
HIPS	-----	NON-CONTEXTUAL
TANKS	LOOKS	CONTEXTUAL
CREW	-----	NON-CONTEXTUAL
VAN	BARN	NON-CONTEXTUAL
OATH	HORSE	CONTEXTUAL
FEAST	FISH	NON-CONTEXTUAL
HOST	HOUSE	NON-CONTEXTUAL
DEN	-----	CONTEXTUAL
CALF	CAT	CONTEXTUAL
GROWL	CAR	NON-CONTEXTUAL
SILK	-----	CONTEXTUAL
LANES	LIVES	CONTEXTUAL
HUT	FOOT	NON-CONTEXTUAL
PIE	CAR	CONTEXTUAL
MUGS	-----	CONTEXTUAL
POND	-----	NON-CONTEXTUAL
BLUSH	LESS	CONTEXTUAL
SLEEVES	SLEEZE	NON-CONTEXTUAL
CLOCK	CLUCK	CONTEXTUAL

CRIB	-----	NON-CONTEXTUAL
SWORD	SLED	CONTEXTUAL
HAY	HOME	NON-CONTEXTUAL
BRAIDS	-----	CONTEXTUAL
DRAIN	DRAWER	NON-CONTEXTUAL
MAP	-----	CONTEXTUAL
TOLL	TOY	NON-CONTEXTUAL
PET	COOK	CONTEXTUAL
WITS	LUCK	CONTEXTUAL
KNOB	MAP	NON-CONTEXTUAL
PILE	CAR	NON-CONTEXTUAL

WORD LIST 2:

LAP	BLOCK	NON-CONTEXTUAL
GROWL	LIE	CONTEXTUAL
BONE	FUN	NON-CONTEXTUAL
HUT	HAT	CONTEXTUAL
SPOON	SPRING	NON-CONTEXTUAL
RISK	LIST	NON-CONTEXTUAL
LANES	MAZE	NON-CONTEXTUAL
RAG	WALK	CONTEXTUAL
DRUG	JOB	NON-CONTEXTUAL
CRASH	SUN	NON-CONTEXTUAL
FEAST	BEACH	CONTEXTUAL
OX	AWER	NON-CONTEXTUAL
PET	PARK	NON-CONTEXTUAL
DEN	GRIM	NON-CONTEXTUAL
MIST	-----	CONTEXTUAL
CHASE	TASTE	CONTEXTUAL
SHARKS	-----	CONTEXTUAL
SAUCE	SOCKS	NON-CONTEXTUAL
RUST	LESS	CONTEXTUAL
ITCH	DEPT	NON-CONTEXTUAL
PLUMS	FLUKE	NON-CONTEXTUAL
CODE	ENCLOSED	CONTEXTUAL
ACHE	GATE	NON-CONTEXTUAL
COUCH	SPOT	CONTEXTUAL
HOOD	HUB	NON-CONTEXTUAL
STING	STAIN	CONTEXTUAL
CURL	OIL	NON-CONTEXTUAL
COUGH	POP	NON-CONTEXTUAL
BUS	BASS	NON-CONTEXTUAL
DIRT	BLAME	CONTEXTUAL
GIFT	JET	NON-CONTEXTUAL
BLOUSE	BAR	CONTEXTUAL
SHELF	SHOUT	NON-CONTEXTUAL
ZOO	PAIN	CONTEXTUAL
MALE	MAJOR	NON-CONTEXTUAL

MASK
PINT
CLOWN

MASS
PLAY
CRIME

CONTEXTUAL
CONTEXTUAL
NON-CONTEXTUAL

WORD LIST 3:

SCREEN
CROWN
GRIN
BARK
BUGS
STRAP
BREAD
ROPE
PORK
KICK
CAP
LOGS
POLE
THROAT
FROGS

STRING
FAST

PART
GUNS

FROG

PORCH
CHECK
CAT
LIES

BRAKE
PRIZE

CONTEXTUAL
CONTEXTUAL
CONTEXTUAL
NON-CONTEXTUAL
CONTEXTUAL
NON-CONTEXTUAL
NON-CONTEXTUAL
CONTEXTUAL
NON-CONTEXTUAL
CONTEXTUAL
NON-CONTEXTUAL
NON-CONTEXTUAL
NON-CONTEXTUAL
NON-CONTEXTUAL
NON-CONTEXTUAL
CONTEXT

WORD LIST 4:

SPRAY
FROGS
DITCH
GRIN
WHEELS
JOINTS
AID
DECK
POLE
DIME
SEEDS
CLUE
BROOM
CRUISE
SCARE
MAT
BARK
RIM
DENT
CROWN
TRUCK
CAP
WHEAT
TACK
BREAD
ROAR

SPY
FLAGS
TOUCH
GUN
WHALES

DUCK
GIRL
BOMB

PAUSE
STAR
MAP
BACK
WOMEN
DUMPED DENT
PLAN
TRIP
CAT

TEST

MOB

NON-CONTEXTUAL
NON-CONTEXTUAL
CONTEXTUAL
NON-CONTEXTUAL
NON-CONTEXTUAL
CONTEXTUAL
NON-CONTEXTUAL
NON-CONTEXTUAL
CONTEXTUAL
NON-CONTEXTUAL
NON-CONTEXTUAL
CONTEXTUAL
NON-CONTEXTUAL
CONTEXTUAL
NON-CONTEXTUAL
CONTEXTUAL
NON-CONTEXTUAL
NON-CONTEXTUAL
CONTEXTUAL
CONTEXTUAL
NON-CONTEXTUAL
NON-CONTEXTUAL
CONTEXTUAL
CONTEXTUAL
CONTEXTUAL

WORD LIST 6:

STRAP	STRAY	CONTEXTUAL
FIST	FIRST	NON-CONTEXTUAL
FIRM	FARM	CONTEXTUAL
SCREEN	SCORE	NON-CONTEXTUAL
PRIZE	-----	CONTEXTUAL
MAST	LOST	NON-CONTEXTUAL
BUGS	-----	NON-CONTEXTUAL
BOWL	-----	NON-CONTEXTUAL
STRIPES	STRAPES	CONTEXTUAL
MATE	MILK	NON-CONTEXTUAL
GANG	-----	NON-CONTEXTUAL
FUN	SUN	CONTEXTUAL
FEE	-----	CONTEXTUAL
RIB	GUN	NON-CONTEXTUAL
BET	-----	CONTEXTUAL
SLICE	-----	CONTEXTUAL
APE	-----	NON-CONTEXTUAL
NAP	-----	CONTEXTUAL
HEDGE	-----	CONTEXTUAL
SLOT	CLOCK	CONTEXTUAL
BROOK	-----	CONTEXTUAL
SCREAM	STORM	NON-CONTEXTUAL
SHED	FLOOD	NON-CONTEXTUAL
WAX	-----	CONTEXTUAL
SPONGE	FUN	NON-CONTEXTUAL
DART	-----	CONTEXTUAL
HERD	-----	NON-CONTEXTUAL
FANS	FRIEND	CONTEXTUAL
DIVE	BAR	NON-CONTEXTUAL
CRATES	FACT	CONTEXTUAL
BENCH	BUS	NON-CONTEXTUAL
LAMP	-----	NON-CONTEXTUAL
FLAME	-----	CONTEXTUAL
CLIP	CLOCK	NON-CONTEXTUAL
POOL	TOUR	NON-CONTEXTUAL
CLERK	CLUB	NON-CONTEXTUAL
ANT	EARTH	CONTEXTUAL
SPY	-----	NON-CONTEXTUAL
PILL	-----	CONTEXTUAL
WRIST	-----	NON-CONTEXTUAL
LUTE	LAKE	CONTEXTUAL
RENT	WATCH	NON-CONTEXTUAL
JAIL	DOG	NON-CONTEXTUAL
HEN	HANDS	NON-CONTEXTUAL
TRAIL	SUN	CONTEXTUAL
TRAP	SOURCE	NON-CONTEXTUAL
SAND	POND	CONTEXTUAL

NON-CONTEXTUAL
NON-CONTEXTUAL
CONTEXTUAL
CONTEXTUAL

BROW
GRAIN
SHEEP
BELT
TUB
GOWN
SAP
MOUSE
SHOCK
PLEA
CARDS
FUR
FLEET
LID
CHEERS
BRUISE
NOTCH
ROW
TASK
AIM
NET
SHELL
CHIP
JUICE
GREASE
CHUNKS
MICE
GUM
BLADE
MOLD
PEG
BREATH
SLAVE
HINT
TRACK
JUNK
THORNS
RAFT

BATH
BRAY
SHEET
BEST
POND
DROWN
SOCKS
KNIGHT
SOCKS
PAIR
CAR
SOUL
SNAKE
ROOM
CRURE
BROOM
MATCH
ROLL
TOP
AIR
SNAP
SAY
CHIC
GREASE
GREET
SKUNK
NIGHT
JOB
GROUND
GLOOM
POEM
BRUSH
SLAYER
TRIP
TACK
RUN
PHONE
ROUGH

NON-CONTEXTUAL
CONTEXTUAL
NON-CONTEXTUAL
CONTEXTUAL
CONTEXTUAL
NON-CONTEXTUAL
CONTEXTUAL
NON-CONTEXTUAL
CONTEXTUAL
NON-CONTEXTUAL
CONTEXTUAL
NON-CONTEXTUAL
NON-CONTEXTUAL
CONTEXTUAL
NON-CONTEXTUAL
NON-CONTEXTUAL
CONTEXTUAL
NON-CONTEXTUAL
NON-CONTEXTUAL
CONTEXTUAL
NON-CONTEXTUAL
NON-CONTEXTUAL
CONTEXTUAL
NON-CONTEXTUAL
CONTEXTUAL
CONTEXTUAL
NON-CONTEXTUAL
NON-CONTEXTUAL
CONTEXTUAL
NON-CONTEXTUAL
CONTEXTUAL

WORD LIST 8:

STRIPS
SHELL

STEPS

NON-CONTEXTUAL
CONTEXTUAL

BELT	-----	NON-CONTEXTUAL
KNIFE	-----	CONTEXTUAL
FUR	-----	NON-CONTEXTUAL
FUDGE	-----	NON-CONTEXTUAL
CHEERS	-----	CONTEXTUAL
STAMP	STAT	NON-CONTEXTUAL
SKUNK	STATE	CONTEXTUAL
PEG	-----	CONTEXTUAL
MOLD	-----	NON-CONTEXTUAL
AIM	-----	NON-CONTEXTUAL
GOWN	-----	CONTEXTUAL
GRAIN	-----	NON-CONTEXTUAL
VEST	-----	NON-CONTEXTUAL
ROW	WALL	CONTEXTUAL
JUICE	JIFF	NON-CONTEXTUAL
BAY	-----	CONTEXTUAL
NOTCH	MATCH	NON-CONTEXTUAL
TASK	-----	CONTEXTUAL
LID	-----	NON-CONTEXTUAL
CHIP	CHECK	NON-CONTEXTUAL
SHEEP	-----	CONTEXTUAL
MICE	KNIFE	NON-CONTEXTUAL
BROW	BAR	CONTEXTUAL
JUNK	JUMP	NON-CONTEXTUAL
PLEA	P	NON-CONTEXTUAL
SHOCK	SAW	CONTEXTUAL
BRAT	-----	CONTEXTUAL
SAP	STA	NON-CONTEXTUAL
YELL	YARD	CONTEXTUAL
THORNS	-----	CONTEXTUAL
JAR	-----	NON-CONTEXTUAL
CARDS	-----	CONTEXTUAL
TUB	-----	NON-CONTEXTUAL
MOUSE	UNLESS	NON-CONTEXTUAL
GUM	DOME	CONTEXTUAL
BREATH	-----	NON-CONTEXTUAL
SLAVE	-----	NON-CONTEXTUAL
NET	NOT	CONTEXTUAL
BLADE	-----	CONTEXTUAL
SPOOL	-----	NON-CONTEXTUAL
BRUISE	-----	CONTEXTUAL
GREASE	-----	CONTEXTUAL
RAFT	-----	NON-CONTEXTUAL
CHUNKS	-----	CONTEXTUAL
CORK	-----	NON-CONTEXTUAL